FM 21-105

WAR DEPARTMENT

BASIC FIELD MANUAL

ENGINEER SOLDIER'S HANDBOOK

June 2, 1943

FM 21–105

BASIC FIELD MANUAL

ENGINEER SOLDIER'S HANDBOOK

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FM 21–105, Engineer Soldier's Handbook, is published for the information and guidance of all concerned. Its purpose is to supplement FM 21–100, Soldier's Handbook, by giving the newly enrolled soldier of the Corps of Engineers, United States Army, a convenient and compact source of basic military engineer information and thus aid him to perform his duties more efficiently.

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BY ORDER OF THE SECRETARY OF WAR:

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(For explanation of symbol see FM 21–6.)

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BASIC FIELD MANUAL

ENGINEER SOLDIER'S HANDBOOK

(This manual supersedes FM 21–105, March 12, 1941.)

CHAPTER 1

THE ENGINEER SOLDIER AND THE CORPS OF ENGINEERS

■ 1. WHAT IT MEANS TO BE AN ENGINEER.—You are an engineer. You are going to build bridges and blow them up. You are going to stop tanks and destroy them. You are going to build roads, airfields, and buildings. You are going to construct fortifications. You are going to fight with many kinds of weapons. *You are going to make sure that our own troops move ahead against all opposition, and you are going to see to it that enemy obstacles do not interfere with our advance. You are an engineer.*

■ 2. YOU AND YOUR JOB.—*a.* You have been chosen to be trained to do a man-sized job for the Army and for your country. To do it well you must keep your eyes and ears open, your mind alert, and be always on your toes. You must keep yourself in top-notch condition. You must become physically tough and an expert at your job. Whether or not our Army succeeds depends a lot on how much better *you* are at *your* job than the *enemy* engineer is at *his.*

b. That's a large order. The Army knows it is; but the Army also knows that if you give the best that is in you, you will do the job well. You will build, tear down, and fight better than any other soldier in the world. You will be an *American* engineer.

■ 3. THE CORPS OF ENGINEERS AND THE FIGHTING TRADITION.—*a. The beginnings of the Corps of Engineers.*—(1) The Corps of Engineers to which you belong has a long record of courage

and of jobs well done. The early engineers set high standards of achievement; the engineers who came later in our history not only maintained those standards, but even improved upon them. Today you and your fellow engineers are carrying on that record; you are going to make the history of the Corps of Engineers even more brilliant.

(2) The first engineers were three small companies organized in the Revolutionary War with the help of French officers. The job of engineers then consisted mainly of constructing field fortifications. The act of the Continental Congress which created the engineers stated that its commissioned officers were "to be skilled in the necessary branches of mathematics; the noncommissioned officers to write a good hand." Those requirements are a long way from the numerous skills our soldiers must have today, let alone our officers and noncommissioned officers.

(3) In 1802 an act of Congress created the present Corps of Engineers. Until the Civil War there was only a handful of engineer troops in our Army. Even during the Civil War the largest number of engineers was four companies. But engineers performed valiant tasks. They fought as infantry in courageous fashion. The engineering jobs of that little body of men should make us proud to carry on their tradition; for example, they threw a 2,000-foot ponton bridge across the James River in a few hours. That's a mark for us to shoot at.

b. The development of the Corps.—(1) Engineers continued to play important roles in every military campaign in our history. It wasn't until the first World War, however, that the great force of engineer troops was really felt. In that war the Corps of Engineers grew from 2,500 men to almost 300,000. The way they fought and did engineer work at Cantigny, St. Mihiel, and Meuse-Argonne is one of the magnificant traditions of the Corps.

(2) Today you are part of hundreds of thousands of troops who make the Corps of Engineers a constructive and destructive fighting force. The chapters which follow will tell you something about the numerous jobs of engineers; they will help prepare you to carry on the important missions of the Corps of Engineers.

CHAPTER 2

ENGINEER TOOLS AND COMMON ENGINEER TASKS

Paragraphs
SECTION I. Engineer tools 4–10
II. Common engineer tasks 11–16

SECTION I

ENGINEER TOOLS

■ 4. IMPORTANCE.—*a.* The engineer soldier is an expert in many things. One of his most important skills is the use of many kinds of tools; some, hand tools, others, power tools. Tools are the basic implements of the engineer. They go along with his unit and are always at hand. With tools the engineer accomplishes many tasks. How well and how quickly he does his job depends upon—

(1) His skill.

(2) His physical condition.

(3) The condition of his tools.

b. All of these are the responsibility of the individual soldier. His own life and the lives of his fellow soldiers depend upon the tools and the skill with which they are used.

■ 5. CARE.—Mainly upon you, the soldier who uses these tools, depends the condition of the tools. When the supply sergeant or his assistant issues tools to you, you become responsible for them. Clean and oil them before you return them. If you are careful in the use of your tools, if you use them in the correct manner, if you are quick to notice and report such things as dullness, battered heads, and rough spots on handles, the job of keeping tools in good condition is easy.

■ 6. SAFETY.—Your tools are sharp. If they are handled improperly you or a comrade may be hurt. Learn to use your tools correctly; the correct way is both the easiest and

the safest way. Here are a few general safety rules. Do not forget any of them.

a. Carry your tools properly. (See fig. 1.)

b. Do not lay sharp tools, such as axes, adzes, and peavies, on the ground where they can be stepped on, fallen on, or run into.

c. When swinging a tool, make sure all others are a safe distance away.

d. Make sure all tool heads are tight on their handles.

e. Do not get in the way of another soldier who is using a tool.

■ 7. USE.—Tools are designed to do work with a minimum of effort. The untrained man tires himself by forcing his tools, gripping them too hard, or using an improper position. The trained man is relaxed, lets his tools do most of the work, and uses his mind, eyes, and hands to guide the tools.

■ 8. ENGINEER TOOL SETS.—Each engineer organization is equipped with the hand tools needed for accomplishing the work usually assigned to it. For convenience in selecting tools for a particular job, they are grouped into sets, such as carpenter, blacksmith, pioneer, and demolition sets. Learn to know the contents of the various squad and platoon sets.

■ 9. HAND TOOLS.—Most of the tools you use are hand tools, the most important of which are discussed below. These discussions are only a guide, however; they are not a substitute for actual training and extensive practice. Apply the things you read here at the first opportunity.

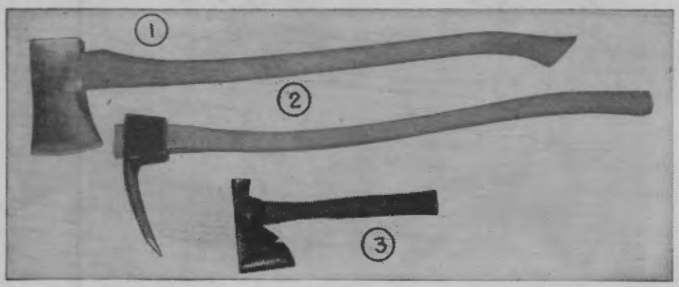
a. Ax (see fig. 2).—Before starting to swing the ax, make sure that there is no interference in any direction. If there are overhanging limbs or undergrowth in the way, clear them out first. Make sure of a firm footing and see that no one is dangerously close. In swinging the ax, be especially careful to stand so that if the mark is missed, or if the ax glances off, it will not strike you. (See figs. 3 and 4.) Keep your eyes on the point to be struck. Never throw the ax or leave it lying on the ground; instead, drive it into a log or stump, or put it in its box. Never use the ax to drive metal stakes.

① ②

FIGURE 1.—Proper way to carry ax, adz, and two-man crosscut saw.

b. Hatchet (see fig. 2).—The hatchet is used for light trimming work such as framing timber, sharpening stakes, or splitting wood. The position of the hand depends upon the desired blow. Hold it near the end of the handle to strike a heavy blow for heavy cuts and near the head for light trimming strokes. The hatchet has a hammerhead which may be used for driving medium-size nails.

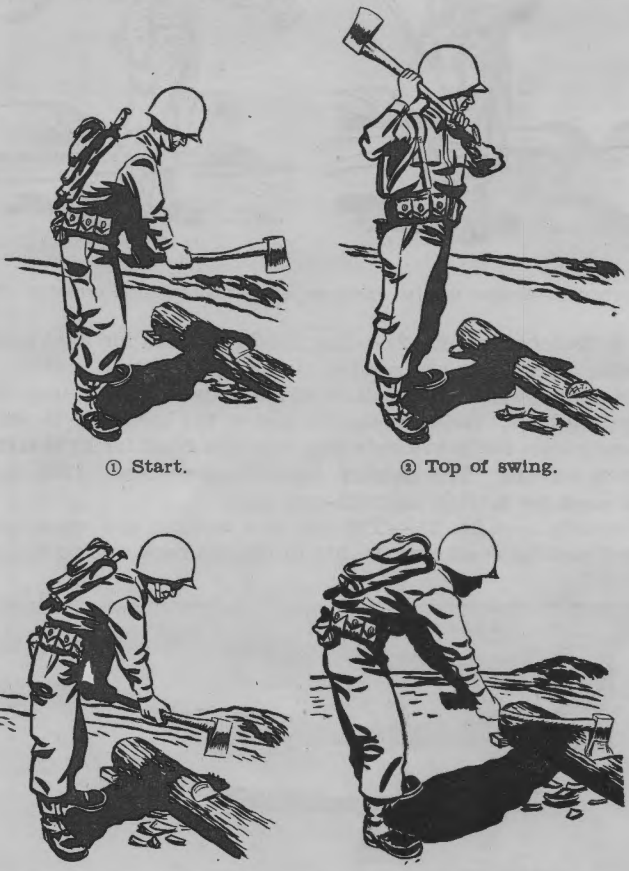
c. Adz (see fig. 2).—The adz is a hewing and smoothing tool used by engineers mainly to remove bark and to square



① Ax. ② Adz. ③ Hatchet.

FIGURE 2.—Hewing tools.

round timber. It must be used carefully or the user may be injured. The correct way to use the adz is to stand astride the log and take short hewing strokes. (See fig. 5.) The log is first scored with chopping strokes, or with shallow cuts made with a saw.



① Start. ② Top of swing.

③ Down swing. ④ Swing completed.

FIGURE 3.—Using the ax on horizontal timber.

① Start. ③ Top of swing.

② Down swing. ④ Swing completed.

FIGURE 4.—Using the ax on standing timber.

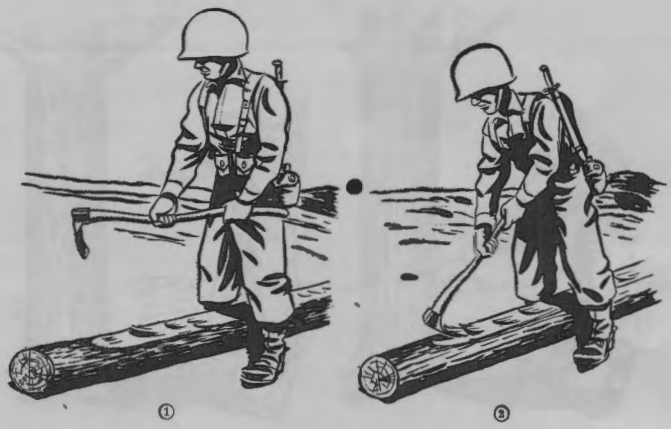


FIGURE 5.—Using the adz.

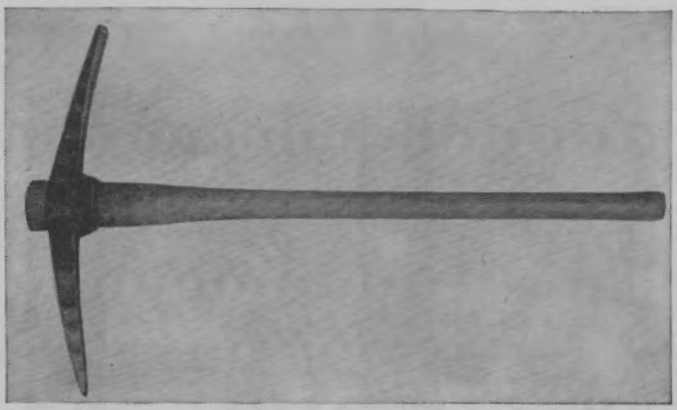


FIGURE 6.—Pick.

d. Pick and pick mattock (see fig. 6).—You should be able to use the pick or pick mattock with either the right or left hand leading. The pick is swung in a manner similar to that used in swinging the ax. (See fig. 3.) To use it with the right hand leading, stand with your feet comfortably placed, left hand at the handle end, right hand near the

pick head, body bent slightly forward, and arms hanging naturally. Carry the pick head behind and above your right shoulder without changing the position of your hands. Swing the pick head forward, allowing the handle to slide through your right hand until your hands meet, and continue the stroke downward. Keep your eye on the point to be struck.

e. Shovels (see fig. 7).—You should be able to use the shovel with either a right- or left-hand swing. After filling it by one of two methods (fig. 8 ① or ②), press the handle down and back to free the shovelful from the rest of the material. Then hold the handle down while raising the weight of the full shovel with the other hand. In casting, allow the handle to slide through the lower hand in the most convenient manner. Do not use a shovel as a pry.

f. Saws.—Saws are of various design, depending upon the kind of work required.

(1) *Hand saws* (fig. 9①).—There are two kinds of hand saws—crosscut and rip. A crosscut saw has knifelike teeth and is used to cut wood *across* the grain. A ripsaw has chisellike teeth and is used to cut wood *with* the grain. The hand saw is used in most common carpentry work. A saw cut should be started by guiding the blade against the thumb of the left hand and drawing the saw backward (fig. 10). Extending the forefinger along the handle aids in guiding the blade. Hold the saw lightly and do not try to push it into the wood; move it back and forth with a full, long stroke, letting it do its own cutting.

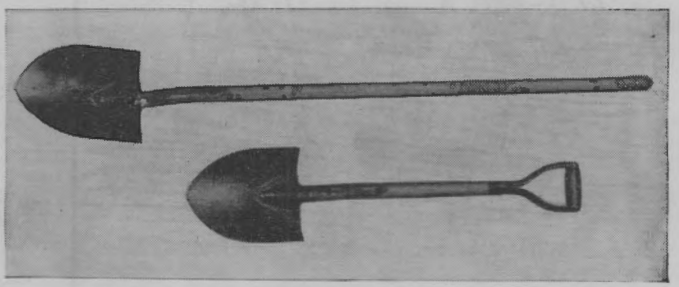


FIGURE 7.—Long-handled and D-handled shovels.

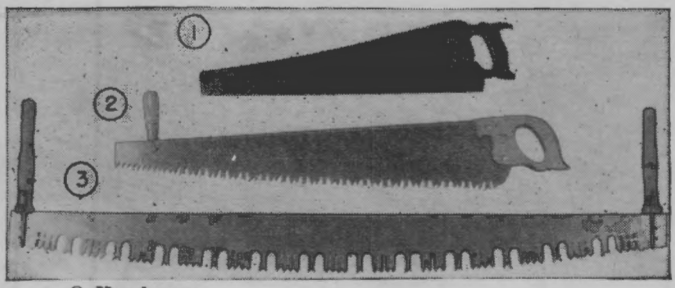
① Filling shovel.

② Filling shovel (alternate method).

③ Start of throw.

④ End of throw.

FIGURE 8.—Using the shovel.



① Hand saw.
② One-man crosscut saw with supplemental handle.
③ Two-man crosscut saw.

FIGURE 9.—Saws.

(2) *One-man saw* (fig. 9 ②).—This saw is equipped with cutting and drag teeth and an extra handle so that, if desired, two men (one at each end) can use it. This saw is used on fairly heavy and rough timberwork where speed is more important than close fits or exact measurements.

(3) *Two-man crosscut saw* (fig. 9 ③).—This saw has two removable handles and is used for cutting standing trees or for heavy framing or cutting. Two men operate it by pulling alternately. Do not push or "ride" the saw; one man's straight pull does the work while the other man relaxes but keeps his hand on the handle.

g. Clawhammer.—The clawhammer is used to drive and draw nails. In driving nails, the hand should be at the level of the nailhead at the moment of impact so that the nail is hit squarely and the force of the blow travels directly along the nail. (See fig. 11.) Similarly, in drawing nails, the force should be directly along the nail, as shown in figure 11.

h. Sledge (see fig. 12).—The sledge is used for heavy driving, rock-breaking, striking rock drills, and for shop and general construction work. It should be swung like a pick. A full stroke gives best results.

i. Maul (see fig. 12).—The maul is a heavy, wooden driving tool, and should be used only to drive wooden stakes and posts. It is swung like the sledge.

j. Peavy (see fig. 13).—The peavy is a gripping and level-action tool, used to roll, haul, or carry heavy timber. To

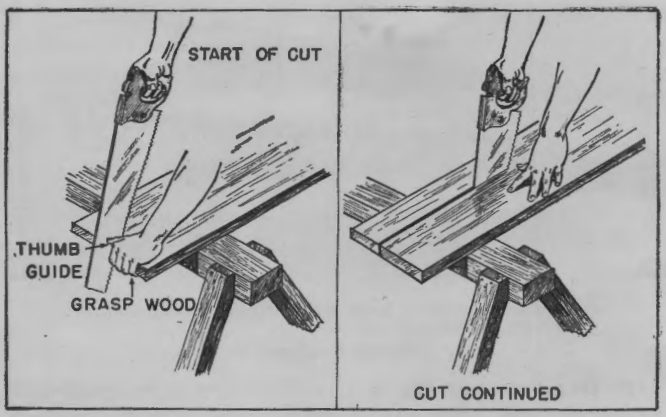


FIGURE 10.—Using the saw.

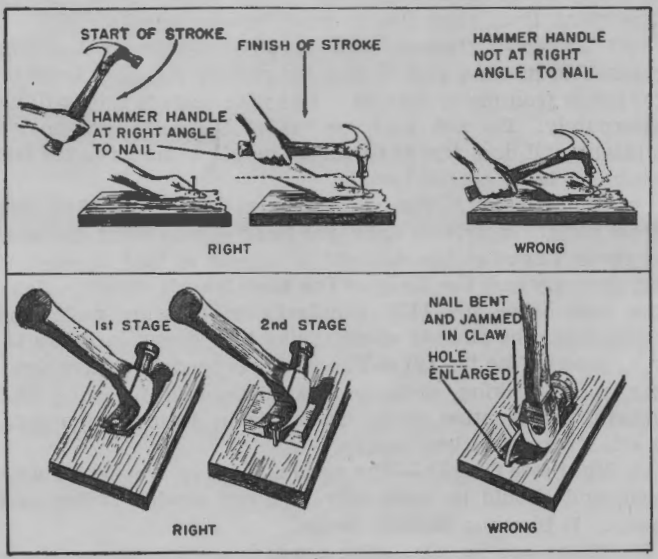
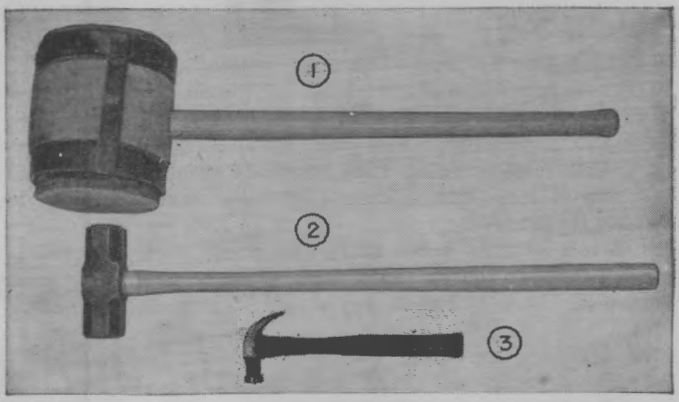


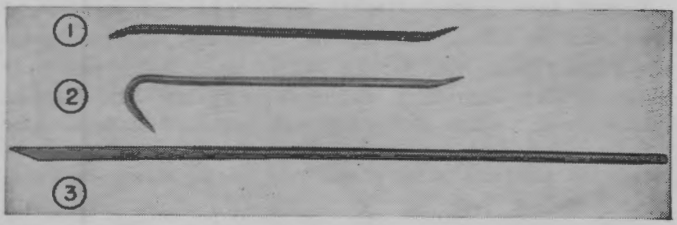
FIGURE 11.—Using the hammer.



① Maul. ② Sledge. ③ Clawhammer.

FIGURE 12.—Driving tools.

FIGURE 13.—Peavy.



① Pinch bar. ② Wrecking bar. ③ Crowbar.

FIGURE 14.—Bars.

carry heavy logs with peavies, men should be distributed equally on each side of the log. (See fig. 40.)

k. Bars (see fig. 14).—There are several kinds of bars, of varied shapes: crowbar, wrecking bar, pinch bar. These are prying tools and are used as levers. In using these bars, secure as much leverage as possible and take small "bites" each time. Be satisfied with relatively small movement at the cost of little effort, instead of doing excessive work to make a large move.

l. Brush hook (see fig. 15).—The brush hook is a sharp, curved cutting tool used to clear underbrush and to trim branches. It should be swung with both hands at the handle end.

m. Machete (see fig. 16).—The machete (pronounced muh-SHAY-tay, muh-SHET-ee, muh-SHET) has a long, extremely sharp blade with a wooden handle. It is used to clear underbrush and trim small branches. It is swung with one hand. Keep it in its sheath when not in use.

n. Earth auger (see fig. 17).—The earth auger is an extremely useful hole-boring tool for the engineer. The 6- and 10-inch sizes are most commonly used. As far as possible, keep the cutting blades out of contact with rocks; use it with care in rocky ground.

o. Wire cutters (see fig. 18).—Wire cutters are especially designed to cut barbed wire. The rubber-covered handles are insulated against live wires. The bent hooks on the searching nose are used to pull the wire toward the operator. The cutters are used with two hands.

p. Side-cutting pliers (see fig. 18).—Side-cutting pliers are used both for holding and cutting, essentially with one hand.

q. Pocketknife (see fig. 19).—The pocketknife has four blades, which include a combination reamer and leather punch blade, a screw driver and bottle-opener blade, a can-opener blade, and a cutting blade. It is equipped with a clevis for attachment to a carrying chain, thong, or cord.

r. Wrenches (see fig. 20).—The two chief adjustable wrenches are the monkey wrench for angular bolts or nuts, and the pipe wrench for round fittings. Note the differences between them.

s. Brace and bit (see fig. 21).—The brace and bit is a boring tool with a variety of bit sizes. It has different bits for wood-boring and for metal-boring. Make sure the wood drills do not come into contact with foreign material such as rocks and nails.

t. Ship-ring auger (see fig. 22).—The ship-ring auger is a long boring tool used to bore holes deeper than those made with the bit and brace.

FIGURE 15.—Brush hook.

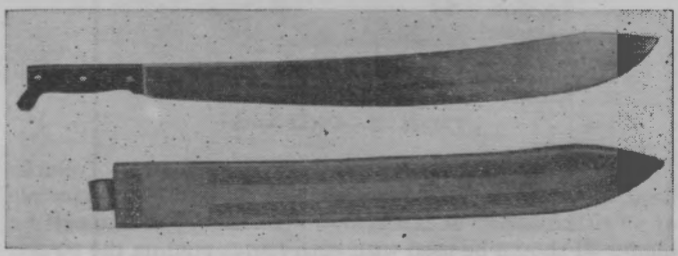


FIGURE 16.—Machete and sheath.

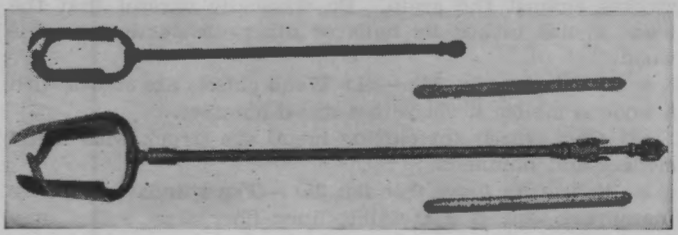
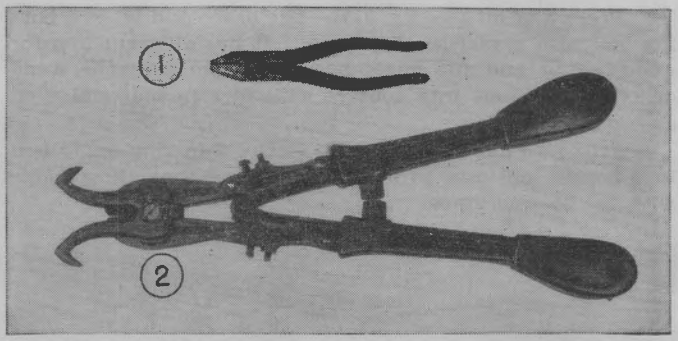


FIGURE 17.—6- and 10-inch earth augers.



② Wire cutters. ① Side-cutting pliers.

FIGURE 18.—Wire-cutting tools.

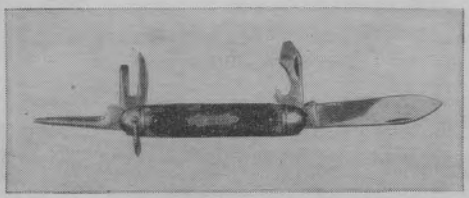


FIGURE 19.—Pocketknife.

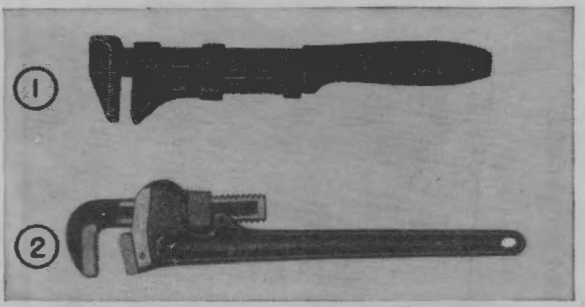
u. Plane (see fig. 23).—There are several kinds of planes used for various kinds of work, but the working principle of all is the same. It is a smoothing tool with a fine cutting blade. It should be used with both hands guiding the stroke. Take long easy strokes with the grain of the wood, short strokes against the grain. Be especially careful that the blade is not nicked by nails or other obstructions in the wood.

v. Chisels (see fig. 24).—(1) Wood chisels are struck with a wooden mallet, never with a metal hammer.

(2) Cold chisels for cutting metal are struck with metal sledges and hammers.

w. Measuring tapes (see fig. 25).—The standard engineer measuring tape is a metallic, linen-fiber tape, rolled in a leather case. Keep it in its case when not in use. Since the

metallic tape stretches slightly, the 6-ft. steel rule should be used for exact measurements.



① Monkey wrench. ② Pipe wrench.

FIGURE 20.—Wrenches.

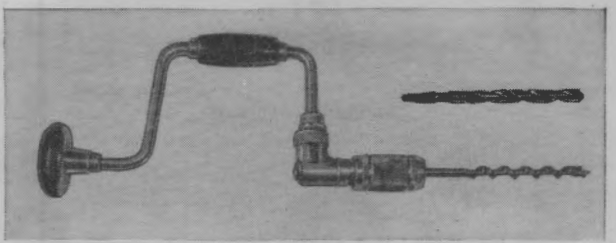


FIGURE 21.—Brace and wood bit, with detached steel-cutting bit.

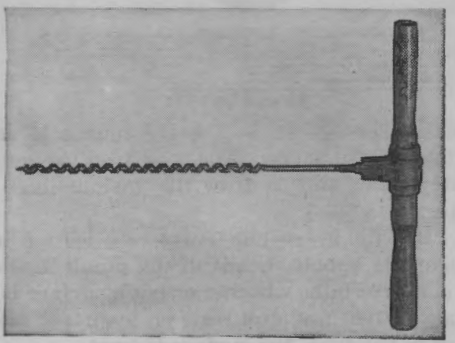


FIGURE 22.—Ship-ring auger.

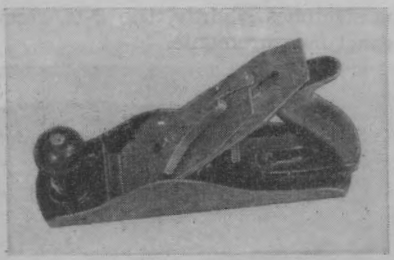
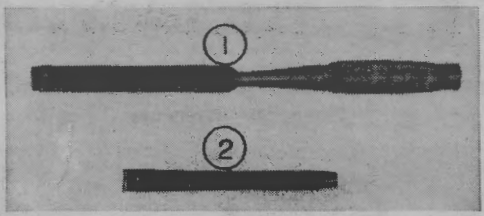
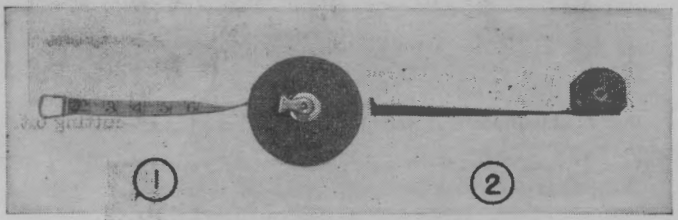


FIGURE 23.—Jack plane.



① Wood chisel. ② Cold chisel.

FIGURE 24.—Chisels.



① Metallic tape. ② Steel rule.

FIGURE 25.—Tapes.

x. Squares (see fig. 26).—The try square is used to test square edges and surfaces. The steel framing square is used to measure angles and to draw the various lines needed by a carpenter.

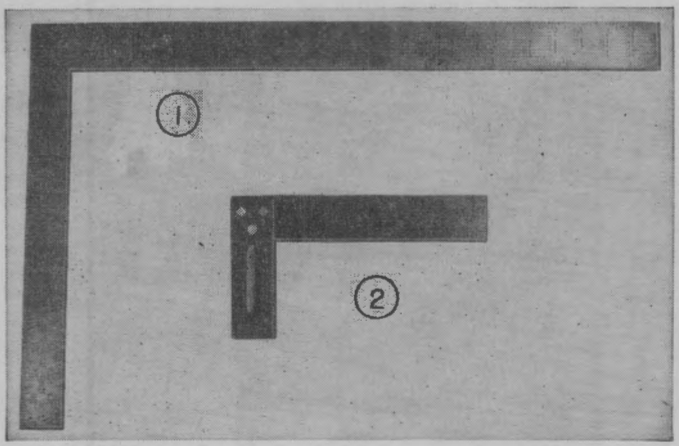
y. Level (see fig. 27).—The level is a precision instrument. By means of the bubble (bead) in the phials in the level, the engineer can determine whether or not a surface is horizontal or vertical. When the level rests on a surface and the bead is centered in the tube, the surface is level.

■ 10. POWER-DRIVEN TOOLS.—The power-driven tools used most frequently by the engineer are tools driven by compressed air from the mobile air compressor unit. These tools save much time and labor, and each engineer soldier should know how to use them. The tools most commonly used are clay diggers, wood and rock drills, pavement breakers, hammers, and wood saws. (See figs. 28 to 34, inclusive.) Figure 35 illustrates the gasoline timber saw.

SECTION II

COMMON ENGINEER TASKS

■ 11. MATERIALS.—Certain prepared building materials, such as standard-size lumber, are available to engineers at supply depots. However, very often the engineers must build their bridges, emplacements, etc., out of local materials found at the site of the work. Therefore, an engineer soldier must be always alert to note local materials, resourceful in his use of these materials, and quick to use them whenever he can.



① Carpenter steel square. ② Try square.

FIGURE 26.—Squares.

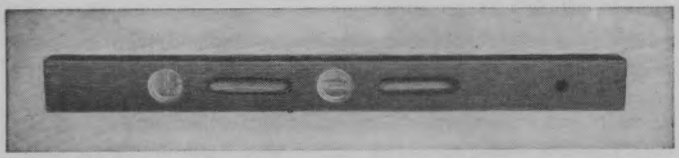


FIGURE 27.—Carpenter's level.

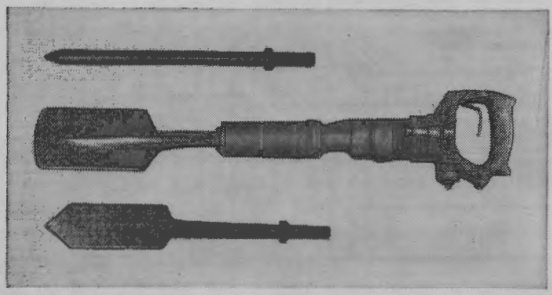


FIGURE 28.—Pneumatic clay digger with spade and moil-point attachments.

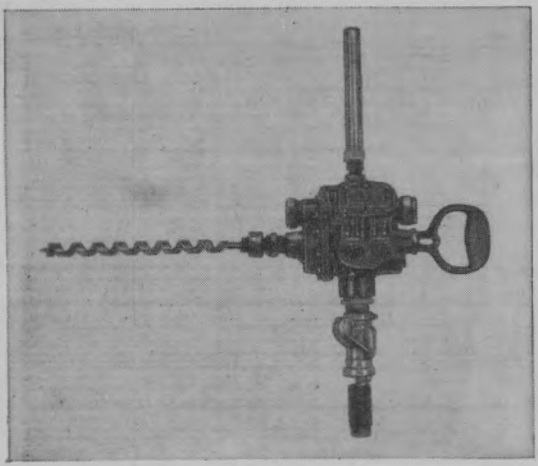


FIGURE 29.—Pneumatic wood drill.

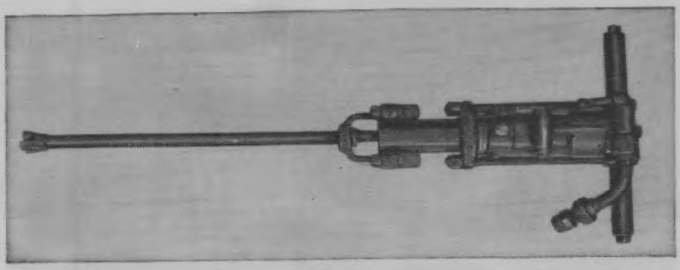


FIGURE 30.—Pneumatic rock drill.

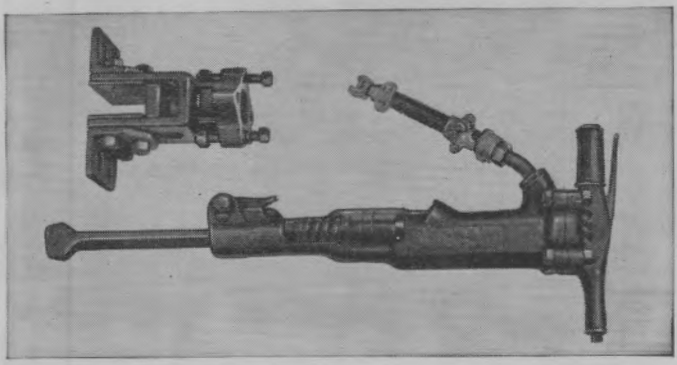


FIGURE 31.—Pneumatic pavement breaker with sheathing-driver attachment.

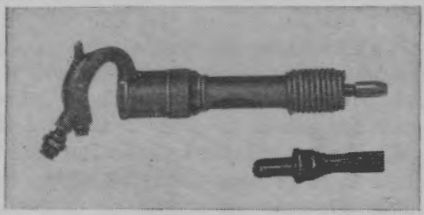


FIGURE 32.—Pneumatic nail driver with chisel attachment.

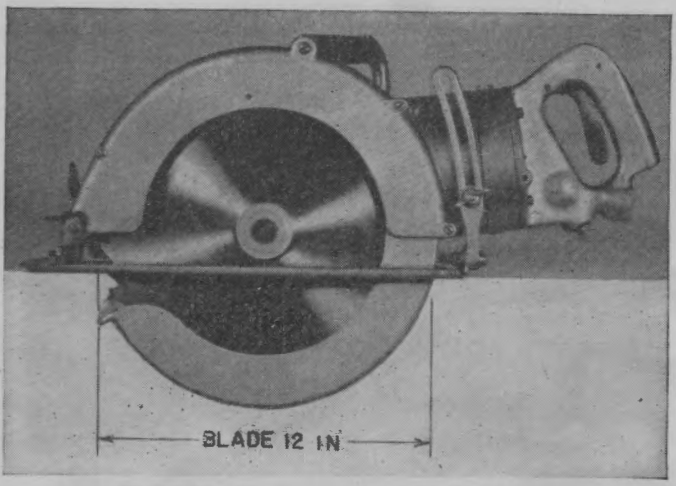


FIGURE 33.—Pneumatic circular timber saw.

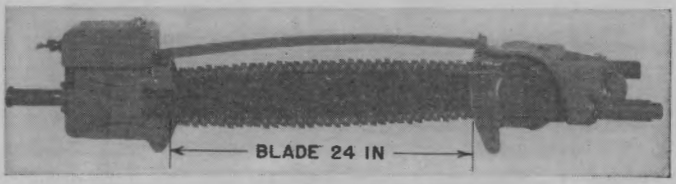


FIGURE 34.—Pneumatic chain saw.

■ 12. FELLING TREES.—With an ax, cut a deep notch near the base of the tree (see fig. 36) on the side toward which the tree is to fall. Then saw the tree on the opposite side to cut the remaining fibers, using steel wedges, if necessary, to keep the saw from binding. To cut the trunk clear of the stump, the saw cut should be started opposite the point of the notch. Where it is desired to keep the base of the tree firmly attached to the stump after felling, as in making a tree road block, the saw cut should be made considerably higher than the notch, so that all fibers will not be severed when the trunk falls. It is often advisable to use guy lines

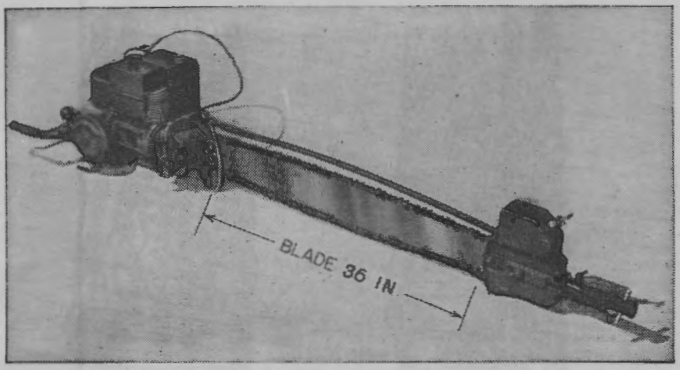


FIGURE 35.—Gasoline-driven chain saw.

to guide a tree in falling and sometimes to use hand or motor power to pull a tree in a desired direction.

■ 13. MAKING TIMBER JOINTS.—In rough carpentry work, the butt joint and the lap joint are used to join or splice two pieces of wood so that they form one continuous piece. (See fig. 37.) The butt joint requires the use of fishplates to hold the ends together. The lap joint is made by overlapping the ends of two timbers and nailing them together. This is the simplest and quickest splice for bracing and like uses.

■ 14. DRIVING DRIFTPINS.—Driftpins (heavy iron spikes) are used to fasten large timbers together. Since driftpins are made of relatively soft iron, holes must first be bored in the wood before the pins are driven. These holes should be slightly smaller in diameter than the pin itself; for example, the hole for a ½-inch driftpin should be made with a 7/16-inch bit.

■ 15. HANDLING LOADS.—*a. Heavy lifts.*—The proper method of lifting heavy loads is to make the legs do the work. (See fig. 38.) Do not bend over from the waist and throw all the strain on the groin and back muscles. Improper methods of lifting often cause a hernia (rupture).

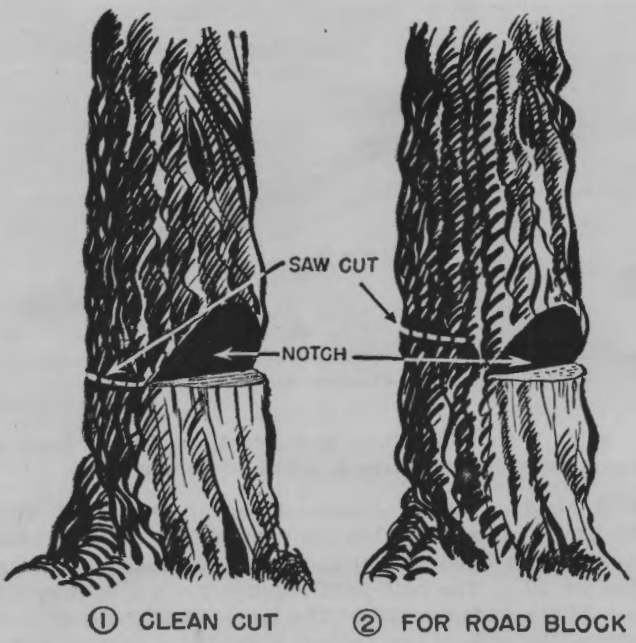
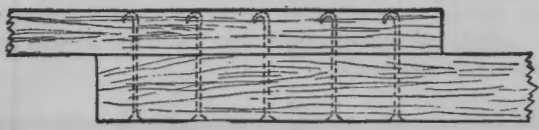


FIG. 36.—How to fell trees.

b. Carrying long or heavy loads.—(1) For long, fairly light objects, such as timber beams or ponton balk, one man takes each end; to keep it from tipping over, the load rests on the right shoulder of the man in front and on the left shoulder of the man in the rear. (See fig. 39.)

(2) For carrying somewhat heavier objects, more men may be used in a similar manner, but it is better to use pick handles, pipes or bars of ample length placed underneath. Two men (on opposite sides of the load) carry each handle. Timber and rail tongs, if available, should be used in the same manner, except that the load hangs below the handles. Figure 40 illustrates the use of the peavy to carry timber. Extremely heavy loads should be handled on pipe rollers, wheeled dollies, block and tackle, or by machines.

① BUTT JOINT



② LAP JOINT

FIG. 37.—Simple timber splices.

① Right.

② Wrong.

FIG. 38.—How to lift heavy objects.

(3) For small but heavy loads, a wheelbarrow should be used with the load placed evenly as far forward as practicable.

c. Carrying chess.—A wide one-man load, such as plank or 10-ton ponton chess, is carried on edge, rear end down, next to the body, with the right hand underneath, near the middle or balance, and the left hand on top steadying and guiding the load. (See fig. 41①.) Sometimes, when the chess is unusually muddy and slippery, or when fatigue necessitates the use of two supporting hands, the chess may be carried with both hands underneath. (See fig. 41②.) When this is done, however, special care must be taken to control the plank so that no one is hit by the ends. For carrying 25-ton ponton chess, two men are needed.

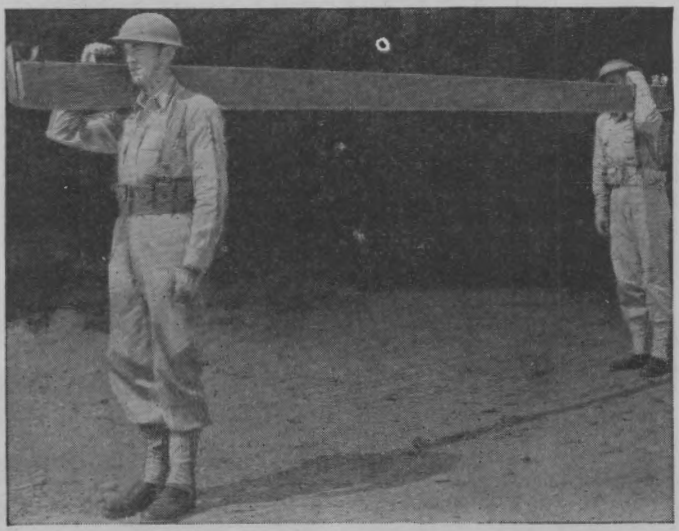


FIGURE 39.—Carrying balk.

■ 16. USING SANDBAGS (see fig. 42).—Sandbags are always laid with the chokes (mouths) tucked under and the side seams and tied ends inside. Grain, cement, and similar

bags can be used, but they should not be more than half-filled or they will be too heavy for a man to handle. Sandbags are used frequently as reveting material to bolster the sides of holes in the ground. Figure 42 shows various ways to use sandbags for revetments. To lay sandbags properly, they must be shaped so that when in place they are roughly half as wide as they are long.

FIGURE 40.—Using the peavy to carry heavy timber.

① First method.

② Alternate method.

FIGURE 41.—Carrying 10-ton ponton chess.

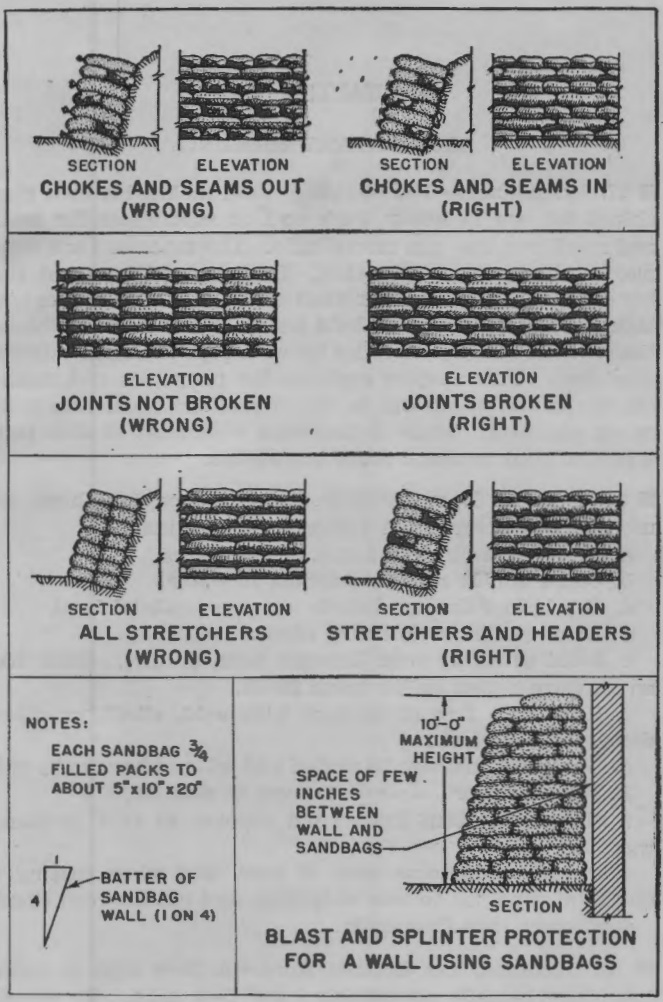


FIGURE 42.—Using sandbags as revetment.

CHAPTER 3

ELEMENTARY RIGGING

■ 17. IMPORTANCE.—The engineer often makes his own machines for use in heavy work and as substitutes for tools and machines that are unavailable. The machines are simple, but they save much labor. By "rigging" is meant the handling of rope (manila or wire) and chains with blocks and tackles to raise, move, or hold heavy loads. The combinations which the engineer rigs up with rope are really simple machines. This chapter explains the principles and methods of rigging, which will be one of your most valuable skills as an engineer. Make a thorough command of this skill a part of your personal Army knowledge.

■ 18. CARE OF ROPE.—Proper care of rope lengthens its usefulness. Observe the following precautions:

a. Do not store in wet, damp, or hot places.

b. Clean muddy rope by washing in water.

c. Dry before storing, but do not use artificial heat.

d. Avoid pulling over sharp edges.

e Avoid dragging rope through sand or dirt. Sand has an abrasive action on the inner fibers.

f. Keep rope free of contact with acid, alkali, or other damaging chemicals.

g. Use knots that can be untied and will not have to be cut.

h. Repair broken strands as soon as possible.

i. Slaken dry, taut lines when exposed to rain or damp weather.

j. Always whip loose ends of rope, and when cutting a length of rope put on two whippings and cut between them.

k. Inspect rope frequently.

■ 19. UNCOILING AND COILING ROPE.—*a.* New rope is coiled into bales usually containing 1,200 feet each. To uncoil, begin with the end in the center of the coil. The rope should

uncoil in a left-hand (counterclockwise) direction. If it uncoils in the wrong direction, turn the bale over, pull the end through the center, and uncoil from the opposite side. (See fig. 43①.)

b. Coil rope in a right-hand (clockwise) direction (see fig. 43②). Mark the end of the rope that will enter the coil last; this is helpful in uncoiling.

■ 20. DEFINITIONS.—*a. Knot.*—A knot is a tie or fastening made with a rope or cord. Types of knots include the following:

(1) *Bend knot* which fastens one rope to another or to a ring or loop.

(2) *Hitch knot,* a temporary knot used to fasten one rope to another, or to spar or post, so as to be readily undone.

NOTE.—These terms are often loosely applied; the same tie, for example, is called a sheet bend, weaver's knot, or weaver's hitch.

(3) *Splice,* a knot joining two ropes, or parts of same rope, by interweaving strands of two parts.

(4) *Lashing,* a knot which ties together objects such as spars or poles by means of a rope. The individual ropes used in this knot are also called "lashings"; rope of this kind, used to lash pontons, is about 18 or 20 feet long and ½ inch in diameter. It has an eye splice at one end and is whipped at the other end.

b. Special terms.—(1) *Anchorage.*—Any means, natural or improvised, for securing guys, ropes, struts, etc.

(2) *Bight.*—Loop formed on rope so that the two parts cross (or lay alongside) each other.

(3) *Chock.*—Bring blocks together until they touch each other.

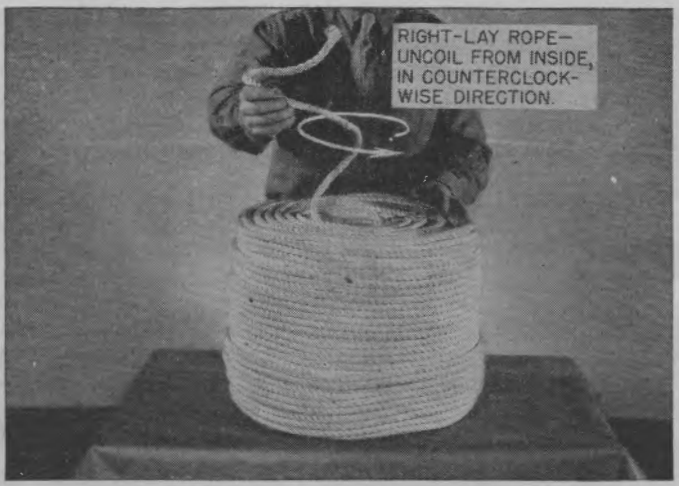
(4) *Frapping.*—Several turns of rope taken around lashing turns, used to keep the lashing tight and in place.

(5) *Guy.*—Rope, chain, or spar attached so as to steady an object.

(6) *Lay.*—The twist of a rope.

(7) *Mousing.*—Closing mouth of hook by lashing to prevent rope or load from becoming dislodged.

(8) *Overhaul.*—To separate the blocks in block-and-tackle rigging.



① Uncoiling.

② Coiling.

FIGURE 43.—Coiling and uncoiling right-lay rope.

(9) *Reeve.*—Thread blocks with rope in assembling block and tackle.

(10) *Return.*—Each part of rope between blocks or between either end and a block.

(11) *Round (run) in.*—Bring blocks closer together.

(12) *Running end (part).*—Free end of rope.

(13) *Seizing.*—Lashing the running end to the standing part of rope.

(14) *Standing end (part).*—Whole rope less running end.

(15) *Tackle.*—Assembly of ropes and blocks.

(16) *Transom.*—Horizontal spar.

(17) *Unlay.*—Untwist rope.

(18) *Whipping.*—Binding or lashing end of rope to prevent unlaying.

■ 21. KNOTS AND THEIR USES.—For any one job a particular knot is the best to use; that is why there are so many knots an engineer must know. Learn to tie all the knots and learn to use them at the proper time. Figures 44 to 48, inclusive, illustrate the most common knots.

■ 22. SPLICES.—The three principal steps in splicing a rope are unlaying the strands, placing the ends together, and tucking the ends of the strands. No attempts should be made to learn to splice without having rope in the hands and actually executing the operations. Marlinespikes or ten pins are desirable, but no special tools are necessary.

■ 23. SHORT SPLICE (fig. 49).—*a.* Short splicing is the best method to join two ropes when an appreciable increase of rope diameter at the splice is not objectionable. A short splice should not be used when the rope will be passed over a pulley.

b. To make the short splice.—

(1) Unlay the strands of each rope for at least five turns.

(2) Bring the ends of the rope together so that each strand of one rope rests between two consecutive turns of the other rope.

(3) To prevent unraveling as the splice is begun, tie a piece of twine around the dark rope at the beginning of the un-

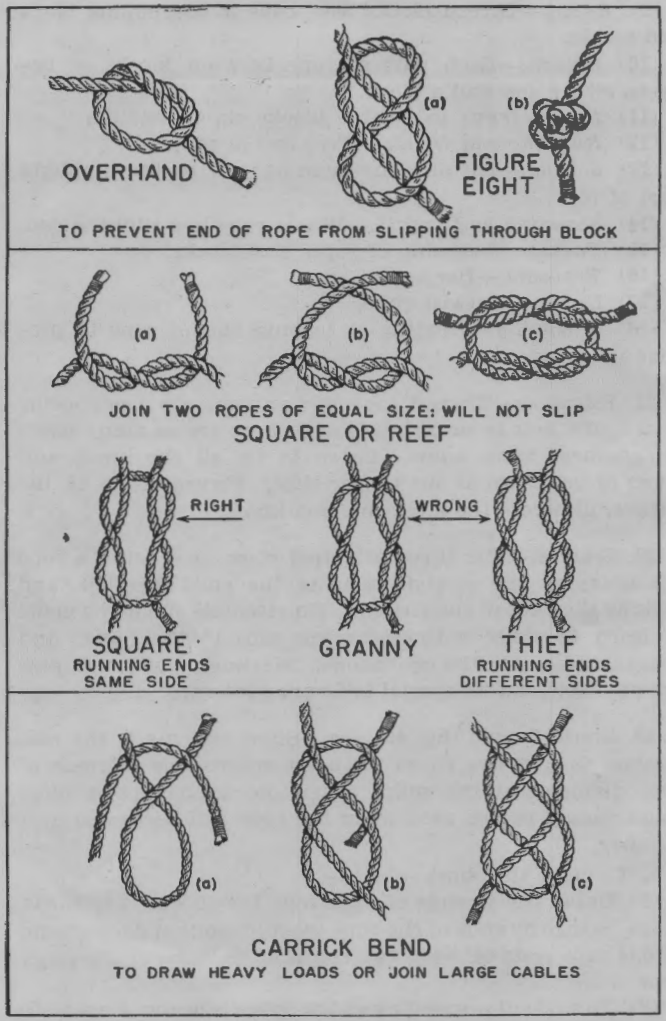


FIGURE 44.—Knots.

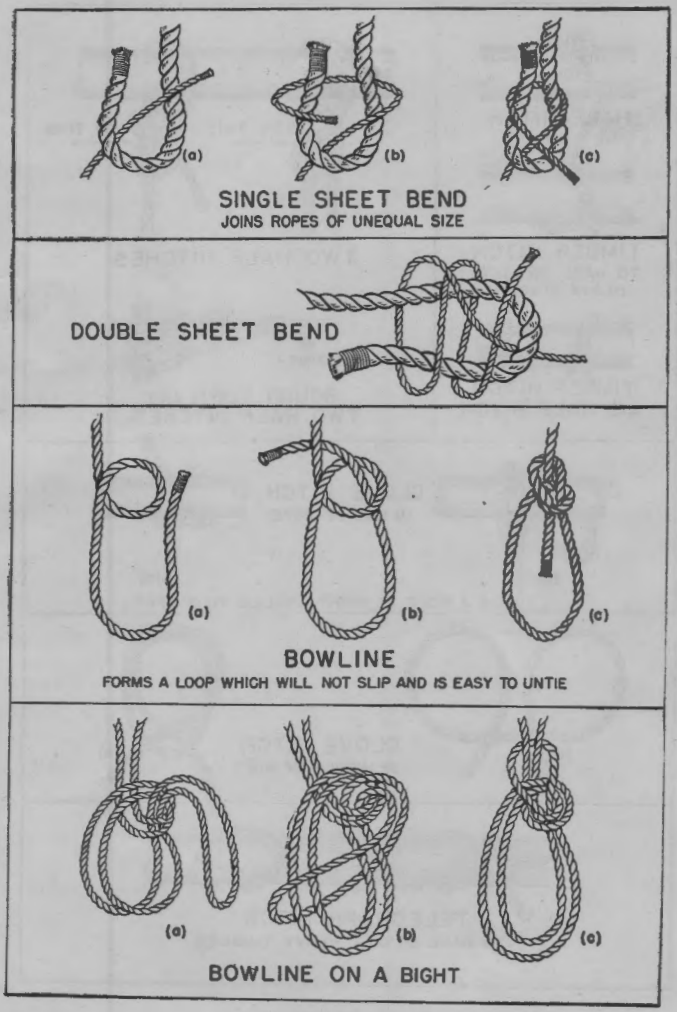


FIGURE 45.—Knots.

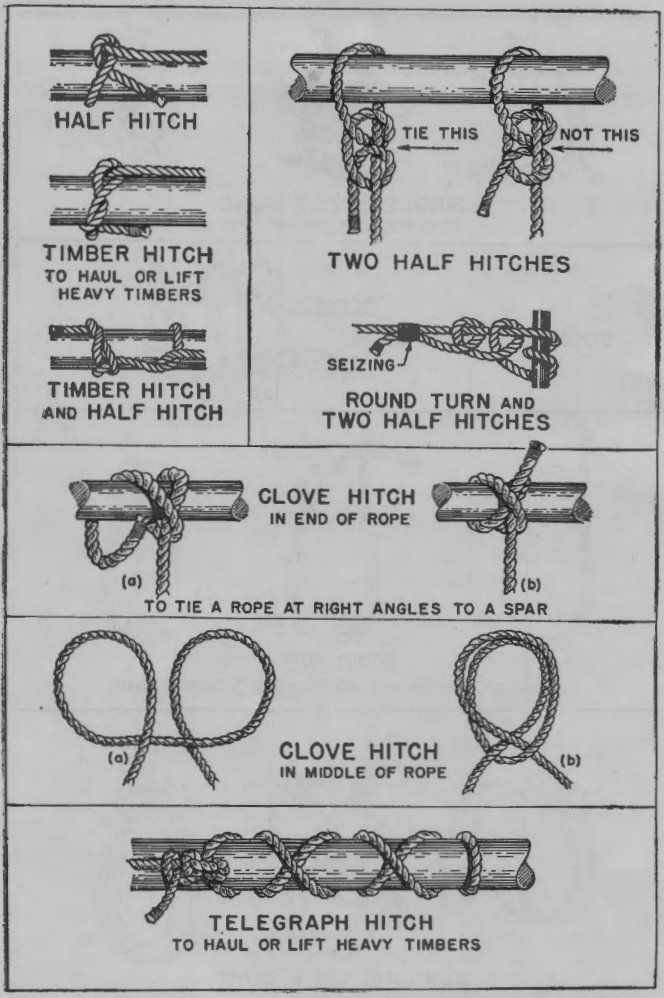


FIGURE 46.—Knots.

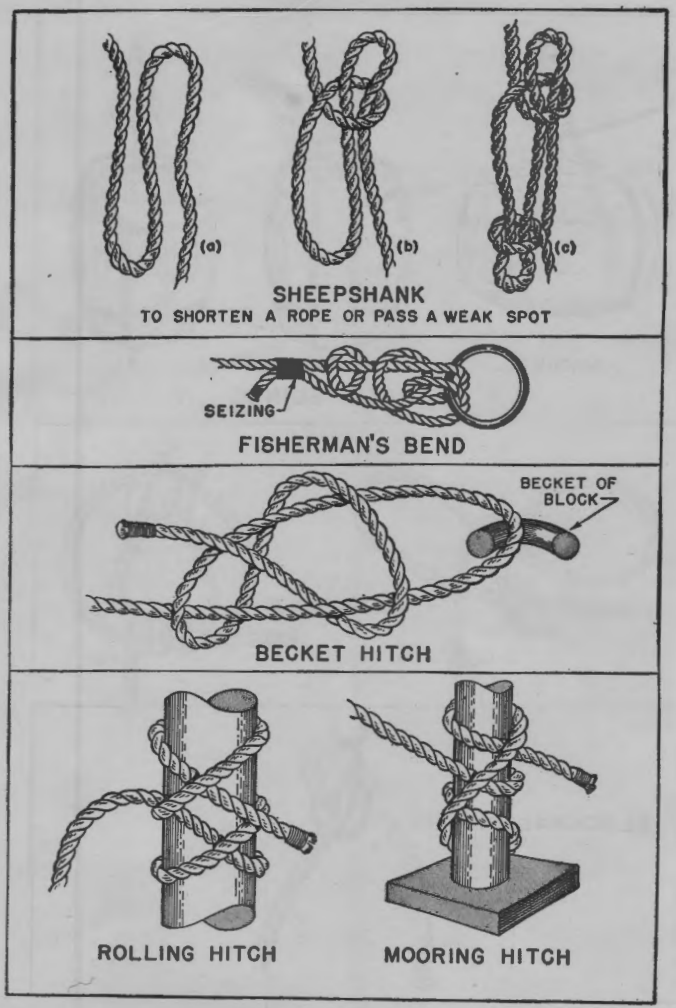


FIGURE 47.—Knots.

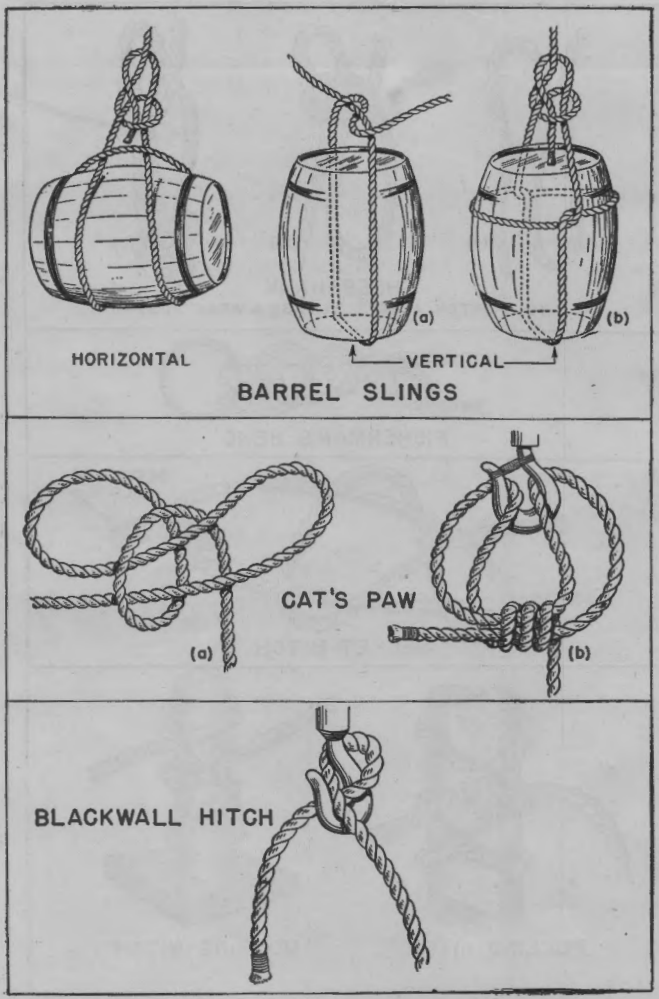


FIGURE 48.—Knots.

raveling; tuck each of the dark strands by passing over one strand and under the next of the white rope.

(4) Remove the twine and tuck the free strands of the white rope over and under the strands of the dark rope in the same manner.

(5) Make at least three more tucks with the first rope, repeat for the white rope, and cut off the loose ends. The ends of the splice may be tapered by continuing the tucking process for two or three tucks, cutting out a few fibers from each strand after each tuck. Rolling the splice (under the foot or under a board) will make it compact and smooth.

■ 24. LONG SPLICE.—The long splice must be used where it is necessary to keep the increase in diameter to a minimum. It also has a neater appearance. The long splice is used to join ropes of equal size when the rope is to run through a block.

a. Stage 1: Unlaying.—To make a long splice in a three-strand rope (see fig. 50)—

(1) Unlay 15 turns from the ends and tie strings about one of the ropes at these points.

(2) Bring the two parts together in the same manner as for the short splice.

(3) Beginning at the point where the two parts are placed together, unlay one of the strands to the right, and lay carefully in its place all but the last five turns of the corresponding strand from the left. This latter operation should follow closely the unlaying of the strand to the right. There are still two pairs of strands left at point *A* where the ends were placed together.

(4) Remove the piece of string and run one of these pairs to the left in the same manner as the first pair to the right; cut off the long ends of the strands (including the two remaining at *A*) about five turns from the main rope.

b. Stage 2: Tucking.—The next part of the splicing consists in tucking the ends of the three pairs of strands. All are tucked in the same manner, as follows: being sure that the ends of the strands pass each other as illustrated in (a) (fig. 50) and not as in (b). As shown in (c), bring the strand from the right up over the nearest strand from the

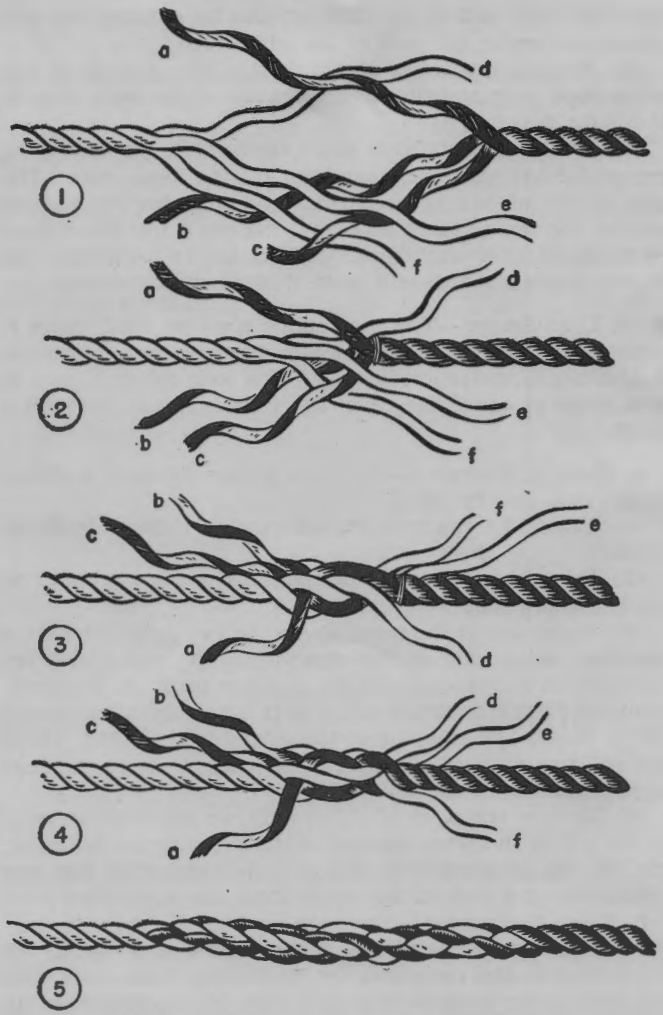


FIGURE 49.—Short splice.

left and under the next strand (d), and (e) give the strand from the left one tuck (f). (g) Each strand should now be given two more tucks in a direction almost at right angles to the direction of twist. When all three pairs of strands have been tucked, cut off the ends and make smooth by rolling.

■ 25. EYE SPLICE.—The eye splice is used to secure a rope permanently to a ring or becket and for making a permanent loop in the end of a rope. To make an eye splice (see fig. 51).—

a. Unlay about five turns on the end of the rope and pass the middle free strand (b) under a strand of the rope so as to form a loop of the desired size.

b. Pass a second free strand (a) under the next strand of the rope.

c. Pass the third free strand (c) under the third strand of the rope as shown in "inset A"; tuck the free strands into the rope (over one strand and under the next) in the same manner as the short splice.

d. Draw all the strands taut and cut off the loose ends.

■ 26. RENEWING A BROKEN STRAND.—Unlay each broken end for about 10 turns; secure a strand of the same size rope about 20 turns in length and lay all but about 5 turns at each end of it into the broken rope in place of the broken strand; join the new strand at each end with an overhand knot with the end of the broken strand; cut the ends of the broken strand to 5 turns and tuck the ends as in the long splice.

■ 27. CARE AND USE OF WIRE ROPE.—Correct handling of wire rope at all times is essential to maximum service. The following precautions should be observed:

a. Reels of wire rope should not be dropped. Weight of rope may break reel, permitting rope to become kinked.

b. Prying with bars should be done on flanges of reel, not on rope.

c. Wire rope should be stored in a dry place and away from corrosive fumes. Outside layer of reel or coil should be protected by a coating of lubricant. Wire in use should be well lubricated.

d. Newly installed wire rope should be worked for a while without load to enable rope to adjust itself to working conditions.

e. To avoid sharp kinks, all loops in slack rope should be straightened before load is applied. To remove a kink, wire

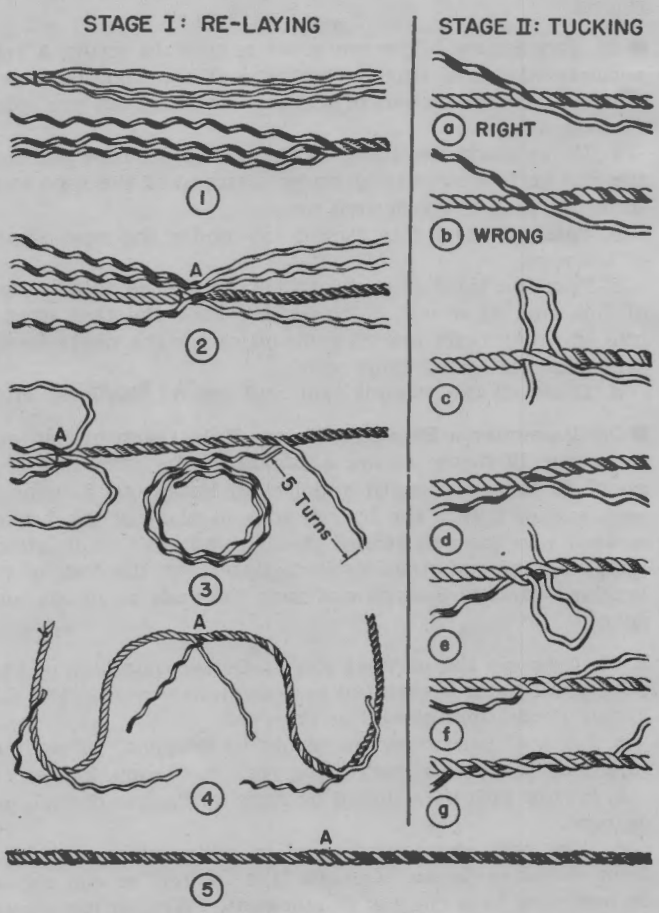


FIGURE 50.—Long splice.

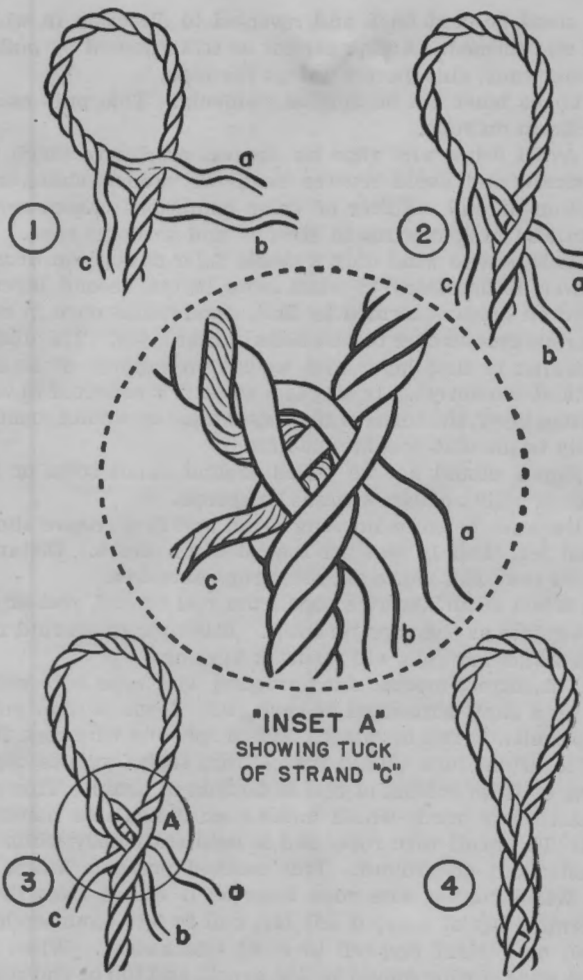


FIGURE 51.—Eye splice.

rope must be bent back and reversed to direction in which kink was formed. A kink cannot be straightened by pulling the rope taut; this merely unlays the rope.

f. Loads must not be applied suddenly. This puts excessive strain on rope.

g. Avoid using wire rope on sheaves or drums which are too small, and avoid reverse bends or sudden changes in direction of pull. Either of these conditions causes severe strain and broken wires in strands and weakens rope.

h. It is best to wind only a single layer of rope on drums; however, if necessary to wind more layers, second layer is wound on grooves formed by first, except that once in each turn rope crosses over two sections of first layer. Third layer is parallel to first layer and wound on grooves of second, except at crossovers. In all cases when it is expected to wind a second layer, the turns of first layer must be wound together tightly to prevent possible binding.

i. Ropes should not be pulled around small trees or flat surfaces. This causes strands to spread.

j. Distance between hoisting drum and first sheave should be not less than 15 feet per foot of drum width. Distances shorter than this cause excessive rope abrasion.

k. When removing wire rope from reel or coil, reel or coil must rotate as the rope unwinds. Attempts to unwind rope from stationary coils will result in kinking.

(1) A correct method for unreeling wire rope is to mount reel on a shaft supported at each end. Rope is then pulled off, permitting reel to rotate. When spooling wire rope from reel to drum, rope should travel from top of reel to top of drum, or from bottom of reel to bottom of drum. This prevents reverse bends which make rope difficult to handle.

(2) To uncoil wire rope, end is held stationary while coil is rolled out on ground. This method prevents kinks.

l. When coiling wire rope loose as it comes from drum, determine lay of rope; if left lay, coil to left (counterclockwise), or if right lay, coil to right (clockwise). When finished, ends of rope should be tied to coil, and top or end should be marked to aid in uncoiling.

m. To wind wire rope on reel or drum, the following rule is convenient to determine proper starting flange; the left

hand is used for left-lay rope, and the right hand for right-lay rope; back of the hand is up for overwinding and down for unwinding. Standing behind and facing drum, the fist represents the drum, and the extended index finger, the rope leading away from drum; thumb indicates at which flange rope should start. Thus, for a left-lay rope overwinding, back of left hand is up, index finger points along rope leading away from drum, and thumb to right indicates that rope should be started on right-hand flange.

n. To avoid accidents, every reasonable effort should be made to stand clear of any wire rope under tension.

o. When rope used on drums and sheaves has had approximately half of its normal use, ends should be reversed to change points of wear.

■ 28. LASHINGS AND SPARS.—*a. Square lashing (two spars at right angles)* (see fig. 52).—To lash two spars at right angles make a clove hitch around the upright a few inches above the transom. Bring the lashing under the transom, up in front of it, horizontally behind the upright, down in front of the transom, and back behind the upright at the level of the bottom of transom and above the clove hitch. Keep the following turns outside the previous ones on one spar and inside on the other, not riding over the turns already made. Make four more turns. Make two frapping turns between the spars, around the lashing, and finish the lashing off either around one of the spars or any part of the lashing through which the rope can be passed. Do not make the final clove hitch around the spar on the side toward which the stress is to come, as it may jam and be difficult to remove. While tightening, beat the lashing with a handspike or pick handle.

b. Three spars for tripod (see fig. 52).—(1) To lash three spars together as for a gin or tripod, mark on each spar the location of the center of the lashing. Lay two of the spars parallel to each other with an interval a little greater than the diameter. Rest their tips on a skid and lay the third spar between them with its butt in the opposite direction, so that the marks on the three spars will be in line. Make a clove hitch on one of the outer spars about 4 inches above

the lashing mark, and take eight or nine loose turns around the three spars. Take a couple of frapping turns between each pair of spars in succession and finish with a clove hitch on the central spar above the lashing. Pass a sling over the lashing and the tripod is ready for raising.

(2) Figure 52 also illustrates an alternate method for lashing three poles together for a tripod.

c. Pair of shears (fig. 53).—To lash for a pair of shears, lay the two spars alongside each other with the butt ends near the place where they are to be erected; rest the points below which the lashing is to be made on a skid. Make a clove hitch around one spar and take the lashing loosely eight or nine turns about the two spars, above the clove hitch, without riding. Make two or more frapping turns between the spars, and finish the lashing off with a clove hitch below the turns on the other spar. Open the butts of the spars and pass a sling over the fork. Hook or lash a block to this sling. Make fast fore and back guys with clove hitches to each spar just above the fork, so that the rear guy pulls on the front leg and the front guy, the rear leg.

d. Gin pole.—A gin pole is used to handle heavy loads. The pole should be no longer than 60 times its smallest diameter; otherwise the pole may buckle under a load.

(1) *Rigging a gin pole* (fig. 54).—Lay the pole on the ground with the base (large end) at the spot where the pole is to be erected. Make a tight lashing of eight or nine turns about 1 foot from the top of the pole; with two or more of the central turns engage the hook of the upper hoisting block. Nail cleats to the pole to prevent the lashing from sliding down the pole. Attach the guy lines with a clove hitch just above the tackle lashing, and nail cleats to the pole just above the guy lines to prevent their slipping off. Lash a block to the butt of the pole about 2 feet above the base in the same manner as at the top of the pole. Now reeve the hoisting tackle.

(2) *Erection* (fig. 54).—Dig a hole where the base of the pole is to rest and anchor the base to prevent its slipping when the pole is raised. String out the guy lines to their respective anchorages and the pole is ready to be raised. Raise the top end of the pole a few feet off the ground and take the slack

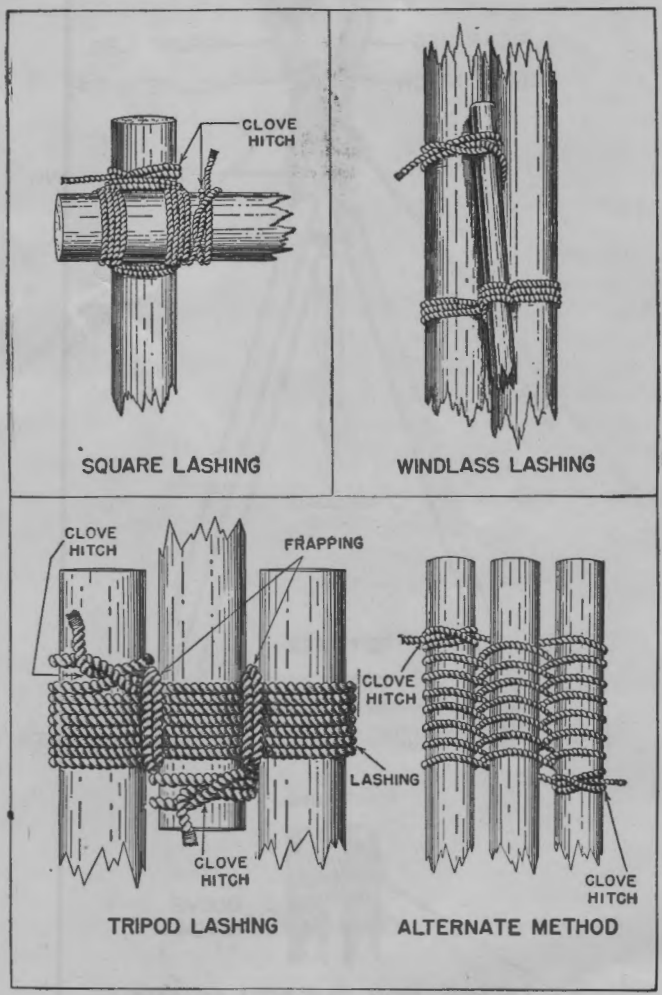


FIGURE 52.—Details of lashings and spars.

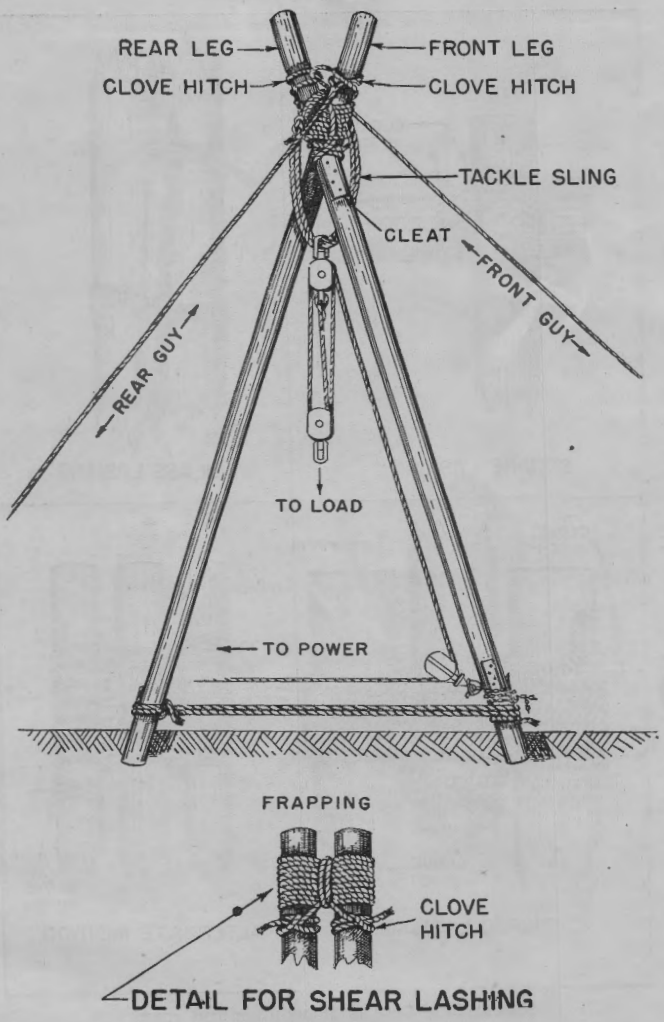


FIGURE 53.—Shears.

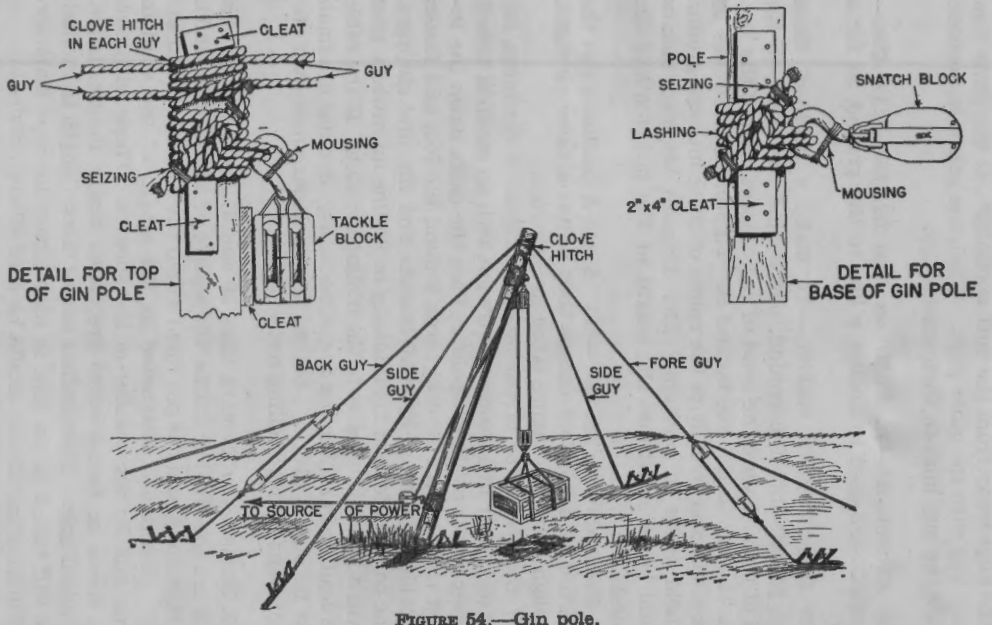


FIGURE 54.—Gin pole.

out of all guy lines. Continue raising the poles by pulling on the guys away from the butt anchorage, at the same time giving way with the other guys. When the pole is in position, secure the guy lines to their anchorage.

■ 29. ANCHORAGES.—*a. Holdfasts* (see fig. 55).—(1) *Use.*—Holdfasts are used to anchor a line to the ground, as for a guy.

(2) *Directions for making.*—To make a holdfast, drive stout pickets into the ground, one behind the other, in the line of pull. Secure the head of each picket, except the last, by a lashing to the one behind it. Tighten the lashings by rack sticks and then drive the points of these into the ground to hold them in position. The distance between pickets should be several times the height of the picket above the ground.

b. Deadman (see fig. 55).—(1) *Use.*—A deadman has the same use as a holdfast except that it has greater strength, although it requires more labor to construct.

(2) *Directions for preparing.*—To prepare a deadman, lay a log or timber in a transverse trench with an inclined trench intersecting it at its midpoint. Pass the cable down the inclined trench, take several turns around the log, and fasten the cable to the log by half hitches and marline stopping. If the cable is to lead horizontally or incline downward, pass it over a log at the outlet to the inclined trench. If the cable is to lead upward, the log is not necessary, but the deadman must be buried deeper. Stakes driven at an angle over the log prevent it from rolling out.

■ 30. BLOCKS AND TACKLES (figs. 56 and 57).—The parts of a block are the shell or frame, the sheave or wheel upon which the rope runs, and the pin upon which the wheel turns in the shell. Blocks are designated by the length of the shell in inches and by the number of the sheaves. Those with one, two, three, or four sheaves are called single, double, triple, and quadruple. The smallest size of block (length in inches) that will take a given rope is nine times the rope diameter. Self-lubricating blocks should be used where obtainable.

a. Definitions.—(1) *Snatch block.*—A snatch block is a

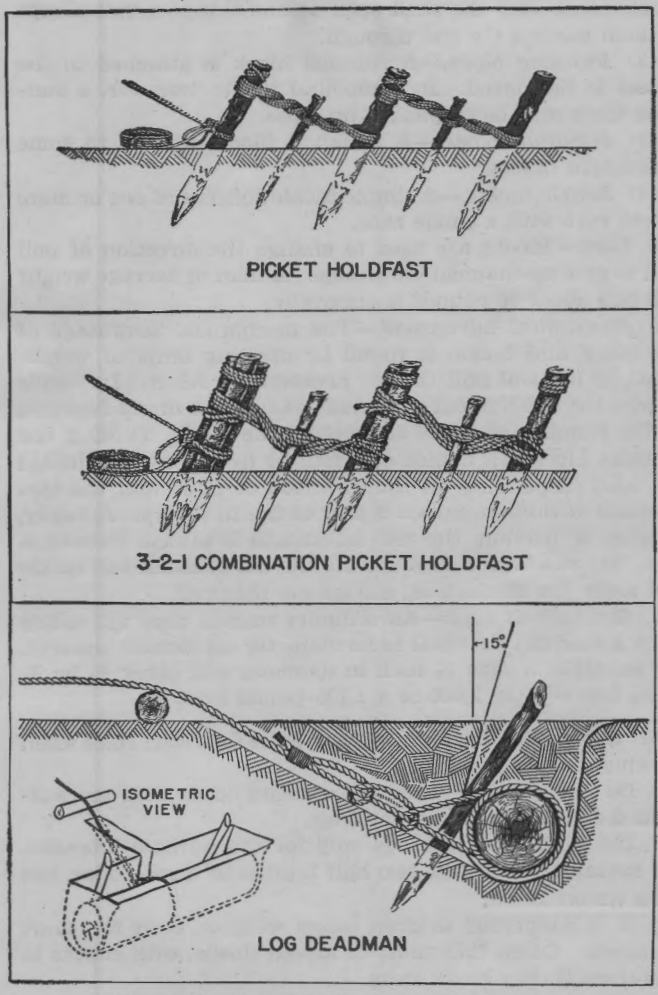


FIGURE 55.—Picket holdfasts and deadman.

single block with the shell open at one side to admit a rope without passing the end through.

(2) *Running block.*—A running block is attached to the object to be moved. In compound tackle, however, a running block may be suspended by ropes.

(3) *Standing block.*—A standing block is fixed to some permanent object.

(4) *Simple tackle.*—A simple tackle consists of one or more blocks rove with a single rope.

b. Uses.—Blocks are used to change the direction of pull and to give mechanical advantage. A man of average weight will pull about 60 pounds horizontally.

c. Mechanical advantage.—The mechanical advantage of the block and tackle is found by dividing units of weight lifted by units of pull (force) necessary to lift it. In simple tackles the mechanical advantage gained is a direct function of the number of ropes *supporting* the load. Thus, if the movable block is a double one, four or five ropes will sustain the load (depending on the direction of pull) and the mechanical advantage gained is four or five in theory. Actually, because of friction, the real advantage is always somewhat less. Figures 57 and 58 illustrate the use of block and tackle and show the mechanical advantage obtained.

d. Strength of rope.—An ordinary manila rope will safely carry a load in tons equal to its diameter (in inches) squared. For example, a rope ¾ inch in diameter will carry ¾ by ¾ or $\frac{9}{16}$ tons=$\frac{9}{16}$ by 2,000 or a 1,125-pound load.

■ 31. SAFETY PRECAUTIONS.—Observe the following rules when working with heavy loads:

a. Do not stand or walk under heavy loads that are suspended from cribs, jacks, or slings.

b. Use knots and lashings only for the purpose intended. For example, do not use two half hitches to hoist a spar, but use a timber hitch.

c. It is dangerous to drop heavy weights, even for short distances. Often they must be moved slowly, with chocks to stop them if they break away.

d. When raising heavy loads with tackle, it is often necessary to follow it up by cribbing; then, if tackle fails, load will be caught on crib.

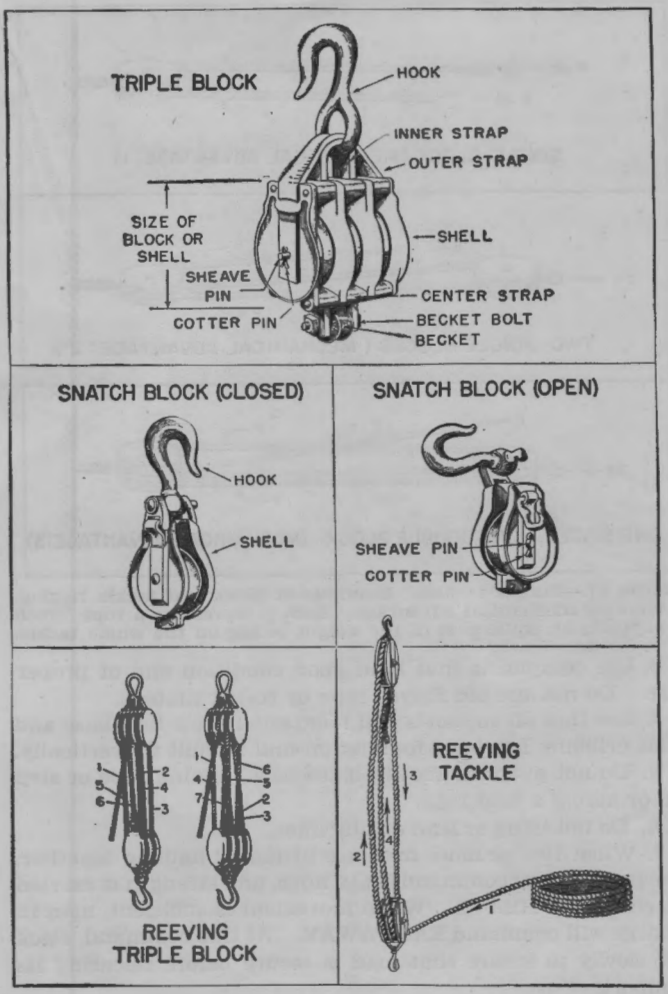


FIGURE 56.—Blocks and tackle.

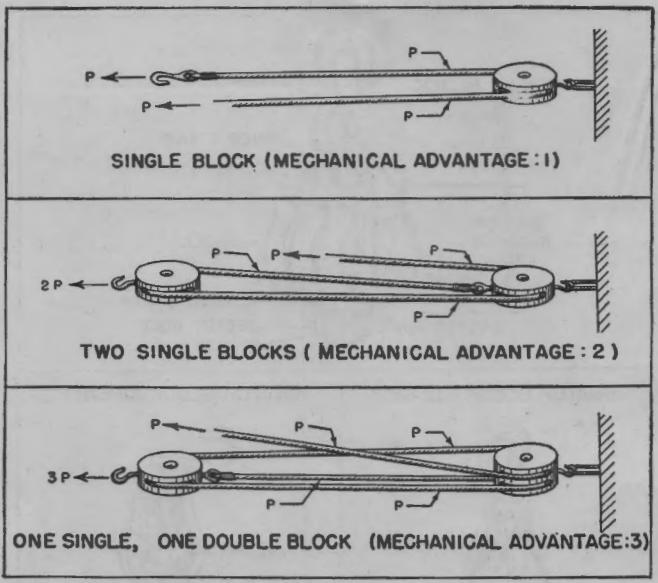


FIGURE 57.—Simple tackles. Examples of block and tackle rigging, showing mechanical advantage. Each p represents a rope which supports an equal part of the weight acting on the whole tackle.

e. Use equipment that is in good condition and of proper size. Do not use old frayed rope or rotted timbers.

f. See that all supports and holdfasts have a firm base and that cribbing has level foundation and is built up vertically.

g. Do not put your foot in bight of a running rope or step on or across a taut rope.

h. Do not hang or lean on guy lines.

i. When two or more men are lifting or hauling together, the preparatory command is LAY HOLD, and strength is exerted at command HEAVE. When movement is sufficient, man in charge will command EASE AWAY. At this command, slack off slowly to insure that load is secure before releasing its support.

j. Whenever possible, have lines snubbed around trees or holdfasts, so that in case of trouble load can be safely held in position.

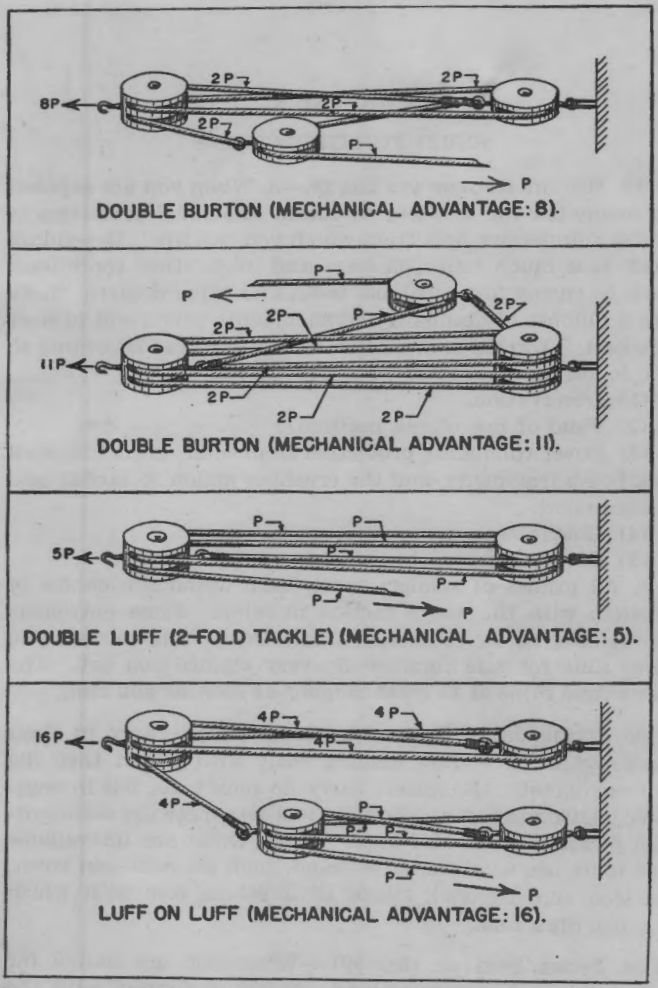


FIGURE 58.—Compound tackles. Examples of block and tackle rigging, showing mechanical advantage. Each p represents a rope which supports an equal part of the weight acting on the whole tackle.

CHAPTER 4

FIELD FORTIFICATIONS

■ 32. HIT THE GROUND AND DIG IN.—*a.* When you are exposed to enemy fire the best way to obtain individual protection is to dig a protective hole from which you can fire. Depending upon how much time you have and upon other conditions, such as enemy fire, available tools, and type of earth, there are a number of standard entrenchments which will protect you best. Terrain is evaluated for military use according to the following factors:

(1) Observation.

(2) Field of fire (firing position).

(3) Cover (including protection from small-arms fire, shell and bomb fragments, and the crushing action of tanks) and concealment.

(4) Obstacles.

(5) Covered approaches.

b. All grades of soldiers must learn automatic *choice of position* with the above factors in mind. Some entrenchments offer better protection than others. Dig the one you have time for and improve it every chance you get. The *important thing is to start digging as soon as you can.*

■ 33. ENTRENCHING TOOLS.—Infantry troops carry in their packs small individual digging tools with which they dig entrenchments. Engineers carry no such tools, but in engineer transportation and pioneer tool sets there are standard-size picks, shovels, and axes. When these are unavailable you must use whatever is at hand, such as meat-can cover, canteen cup, bayonet, sticks, or anything else with which you can dig a hole.

■ 34. PRONE SHELTER (fig. 59).—When you are halted for more than a few minutes and are out of contact with the enemy, the prone shelter should be built. It is comparatively easy to construct and it protects you from bomb

fragments. You can lie down in it and rest. *But it does not protect you against the crushing action of tanks.*

■ 35. SHELL-HOLE POSITIONS (fig. 60).—In a shell-pitted area, improved shell holes offer quick protection and some concealment with only a small amount of labor.

■ 36. FOX HOLES (figs. 61 and 62).—Fox holes afford maximum cover from any kind of fire, and also give protection from tanks.

■ 37. WEAPON EMPLACEMENTS.—Engineers not only build their own entrenchments and emplacements, but they also may be called upon to build such positions for other troops. Therefore you should be familiar with the design of emplacements for infantry weapons as well as your own weapons. Figures 63 to 66, inclusive, show machine-gun emplacements. Figure 67 is an emplacement for the 37-mm antitank gun. In order to illustrate clearly the design of these emplacements, concealment and camouflage have been purposely omitted. Remember that alternate positions are habitually dug for each weapon, as a weapon that is fired from one place cannot survive for long.

■ 38. REVETMENT.—The walls of entrenchments sometimes need support. The process of bolstering these walls is called reveting. Revetments may be made with sandbags (fig. 42) or with pieces of wood (fig. 68).

■ 39. BARBED WIRE.—*a.* Barbed wire is a difficult obstacle for men, animals, and wheeled vehicles. It is often necessary for engineers to construct barbed-wire fences. Figure 69 is a diagram of a double-apron fence. The layout of such a fence is complicated and is not taken up here. However, there are numerous little jobs in the construction of a barbed-wire double-apron fence which may cause trouble if they are not accomplished correctly. These are mostly tricks of fastening wire to posts. Figure 70 shows a screw-type picket. Practice making the connections shown on figures 71 and 72. Figure 73 shows how to roll a barbed-wire bobbin.

b. Clearing barbed wire is sometimes an engineer's job. Figure 74 shows how to cut barbed wire so as to make as little noise as possible. When speed is more important than silence, barbed wire is blown by means of a bangalore torpedo. (See par. 48.)

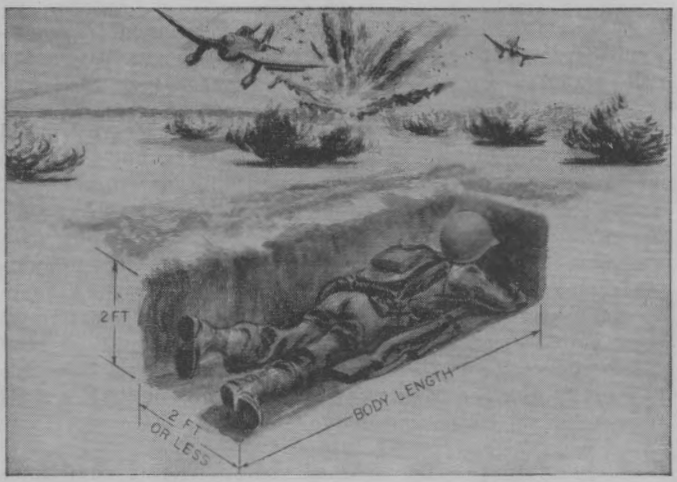


FIGURE 59.—Prone shelter.

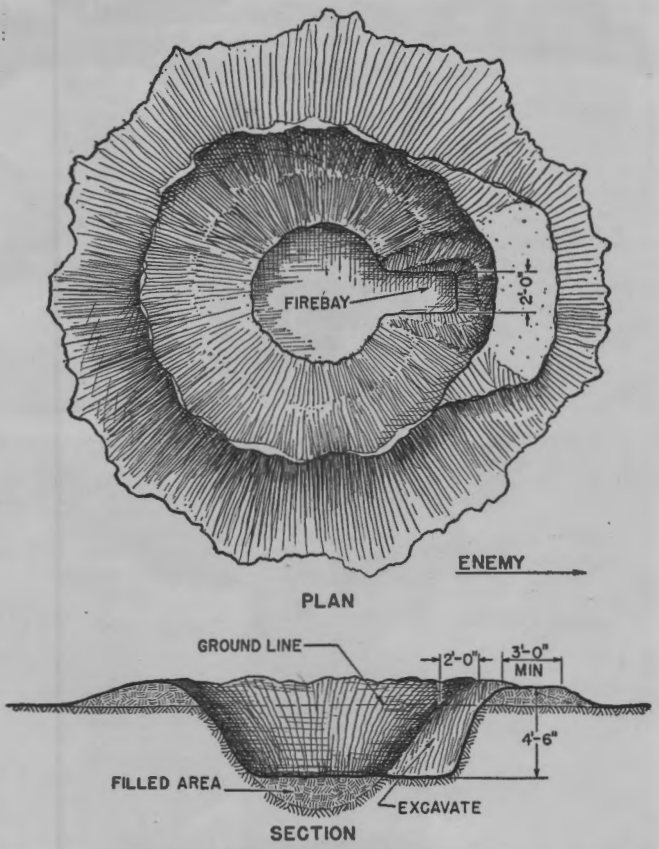
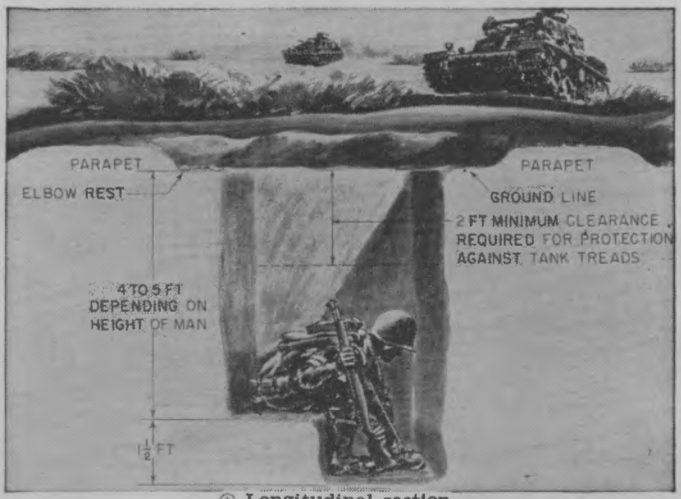
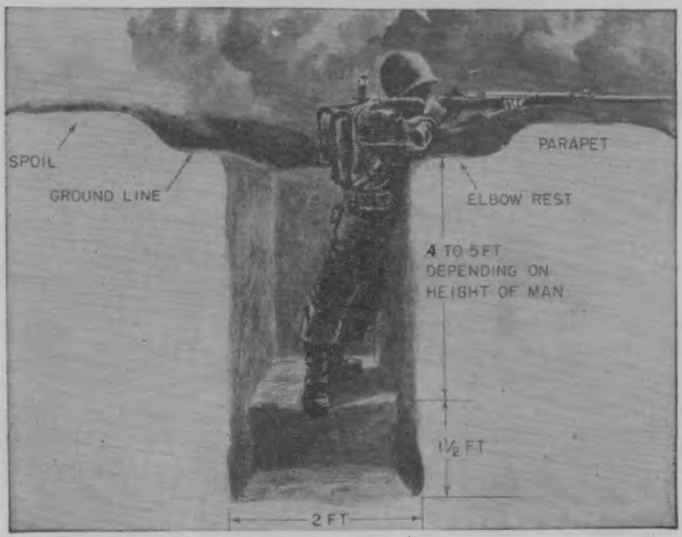


FIGURE 60.—Shell-hole position, showing improvements for one man.



① Longitudinal section.



② Cross-section view.

FIGURE 61.—One-man fox hole.

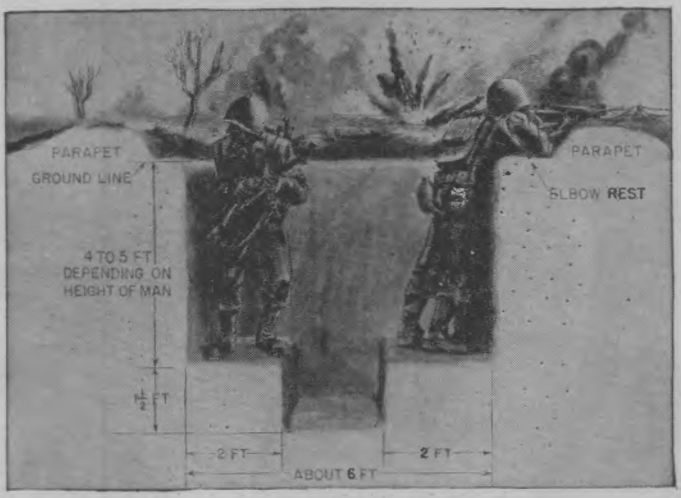


FIGURE 62.—Two-man fox hole.

FIGURE 63.—Caliber .30 machine-gun (heavy) emplacement, open shallow type.

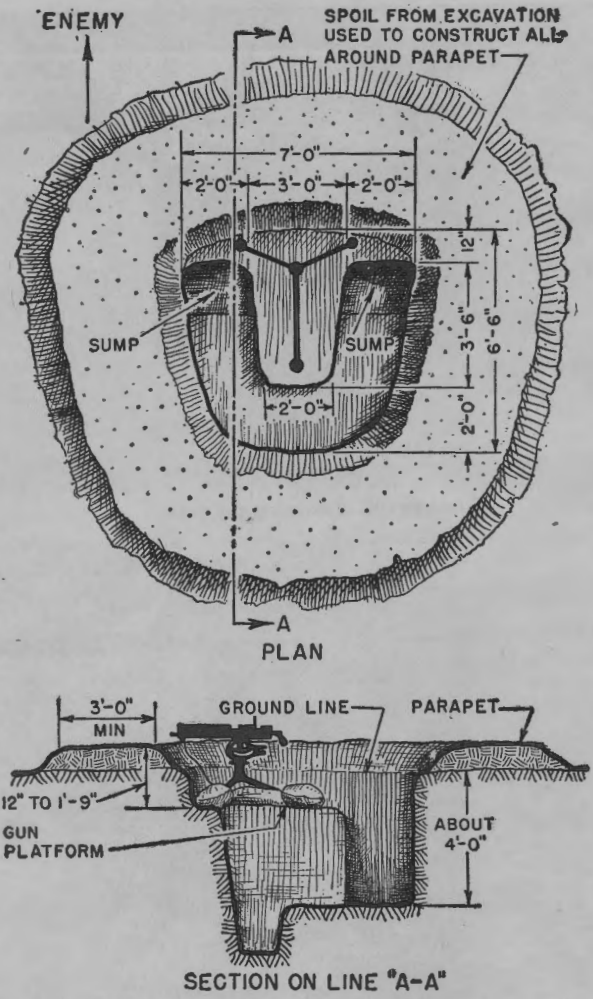


FIGURE 64.—Caliber .30 machine-gun (heavy) emplacement, open standing type.

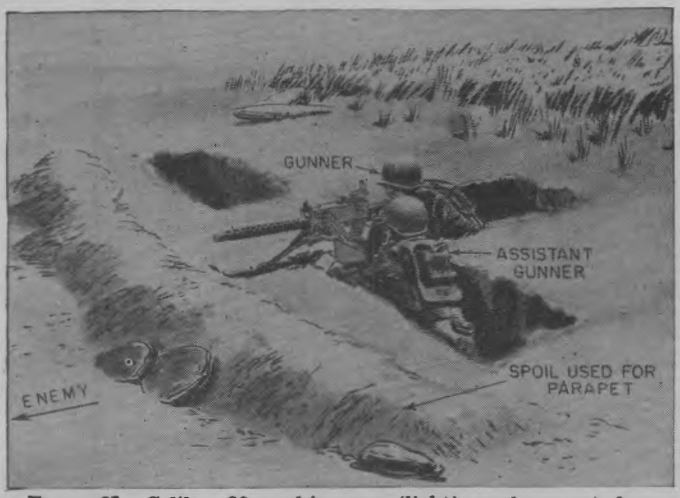


FIGURE 65.—Caliber .30 machine-gun (light) emplacement, fox-hole type.

FIGURE 66.—Caliber .30 machine-gun (light) emplacement, open standing type.

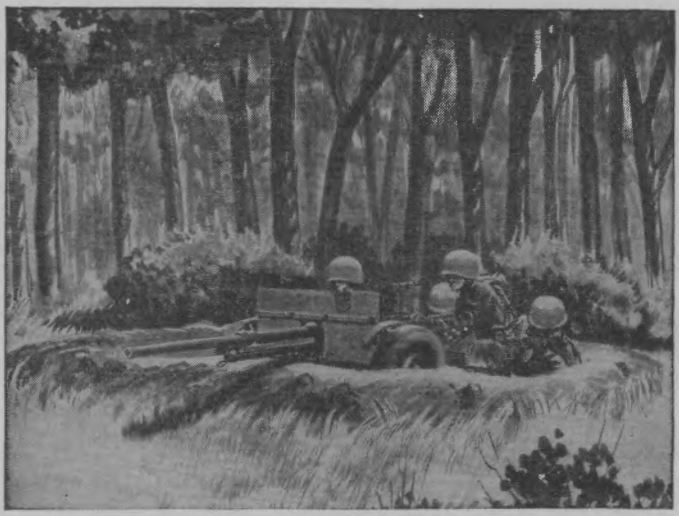


FIGURE 67.—37-mm antitank gun and emplacement.

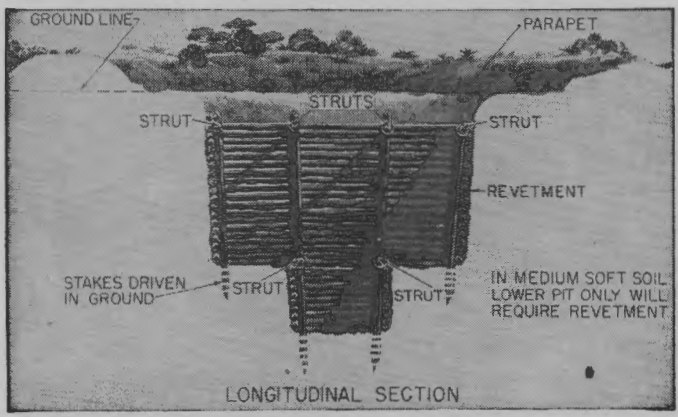


FIGURE 68.—Two-man fox hole, showing method of revetment.

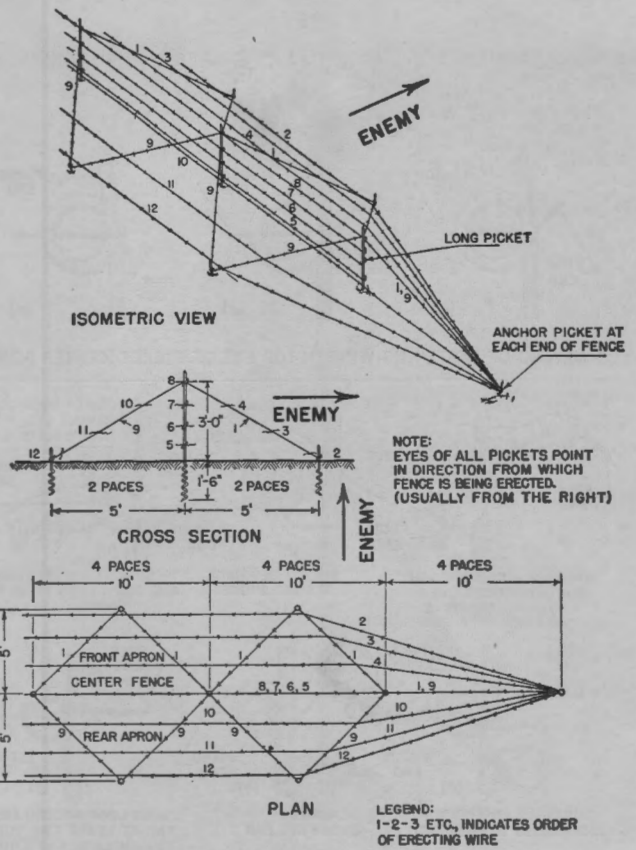


FIGURE 69.—Barbed wire double-apron fence.

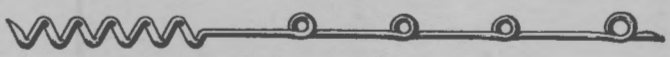
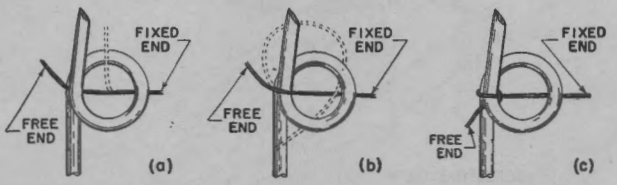
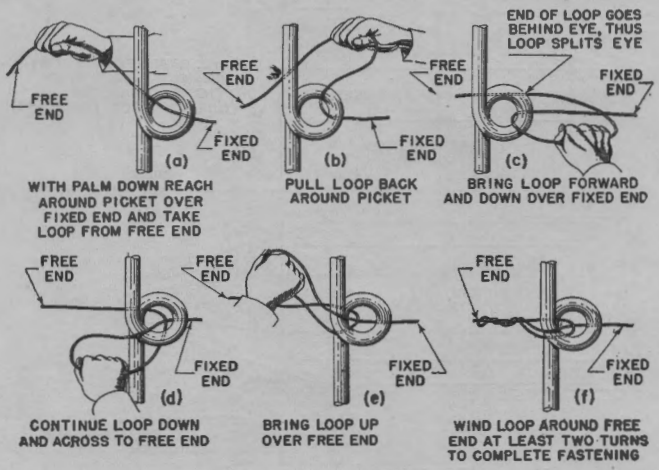


FIGURE 70.—Long screw-type picket.



METHOD OF FASTENING WIRE IN TOP EYE OF PICKET (CENTER FENCE)



FASTENING WIRE TO INTERMEDIATE EYE (EYE POINTING TO FIXED END)

FIGURE 71.—Tying barbed wire to pickets.

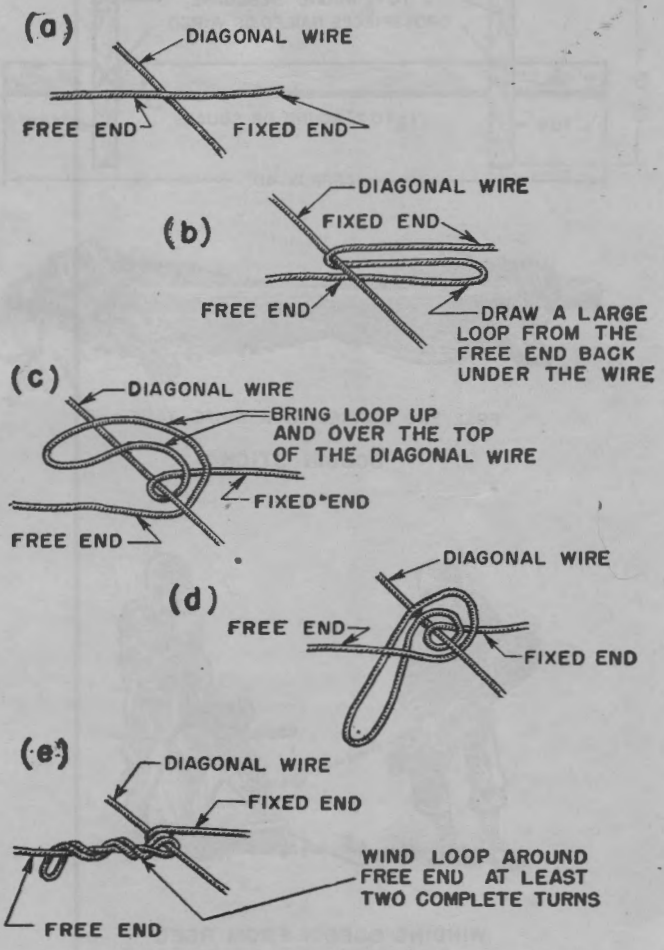
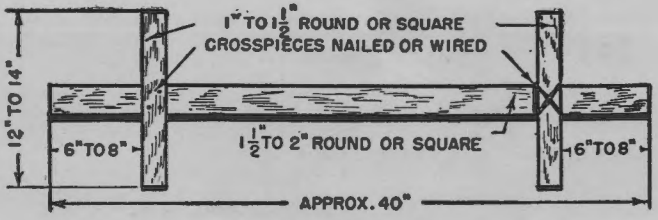
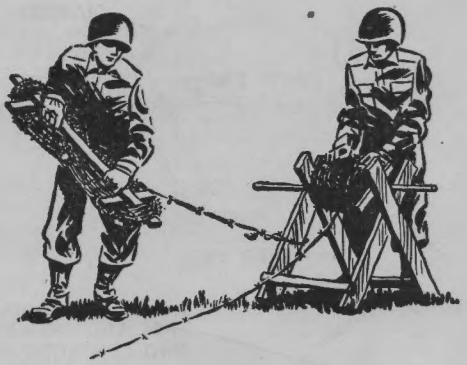


FIGURE 72.—Fastening horizontal wire to diagonal wire.



BOBBIN STICK



WINDING BOBBIN FROM REEL

FIGURE 73.—Making bobbins.

FIGURE 74.—Cutting barbed wire.

CHAPTER 5

CAMOUFLAGE

■ 40. WHAT IS CAMOUFLAGE?—*a.* Camouflage is a weapon—one of the most important we have. It consists of all the work we do to hide ourselves and our equipment from enemy observation. By means of careful camouflage we can protect ourselves, confuse the enemy, cause him to waste valuable ammunition, or make him fall into a trap.

b. Remember that if the enemy can't see us, he can't hit us effectively. If you learn to understand and to carry out the important principles of camouflage, you can give your Army a head start on the enemy. However, if you, an individual soldier, make a single mistake, you may give away the position and plans of your whole battalion. That's how important camouflage is.

c. Everyone in the Army must know how to use camouflage. But as an engineer you are expected to be an expert at it. We must learn this job so well that when other branches of the service come to the engineers for camouflage advice and help, we will be able to do the job. *Make good camouflage an intimate part of your daily life.*

d. FM 21–45 and 5–20 contain additional information about deceiving the enemy by means of camouflage. Ask your platoon leader for these manuals and read them carefully.

■ 41. INDIVIDUAL CONCEALMENT.—You must learn to hide your own presence and movements. Remember, you can be seen from both the ground and the *air*. The aerial observer is one of our deadliest enemies, but you can beat him if you are careful.

■ 42. HINTS ON INDIVIDUAL CAMOUFLAGE.—*a. Select your positions and routes of advance beforehand.*

b. Move rapidly between well selected positions by "leaps and bounds."

c. Learn to work and move silently.

d. Keep in shadows (fig. 75).

e. Break up form. Use branches and leaves to break up your outline (fig. 76).

f. Break up solid areas of color and blend them with their surroundings. Camouflage your tent with natural materials (fig. 78).

g. Avoid a reflected light or shine. Paint or darken your face to confuse enemy snipers.

h. Hide earth you dig from ground and change the regular outline of your fox hole (fig. 77).

■ 43. CAMOUFLAGE DISCIPLINE.—In modern war, not only individuals but whole armies, their buildings, guns, and trucks, are camouflaged. Around installations it is important that the pattern of the ground be unchanged, especially as viewed from the air. *A single set of footprints in a field is visible from the air.* A single flashing mess kit can reveal the position of a company. Observe all rules of camouflage discipline.

a. Don't make new tracks.

b. Keep on existing paths and roads.

c. Don't throw refuse or spoil where it can be seen.

d. Do nothing that will change appearance of ground from the air.

■ 44. ARTIFICIAL MATERIALS.—*a.* Sometimes artificial materials must be used in camouflage. The Army furnishes nets of various sizes for this purpose. Learn to use them properly. The two main camouflage nets issued by the Army are shrimp nets (with ¼-inch mesh), which are used only as drapes, and fish nets, which are *garnished* with strips of colored cloth and may be used either as drapes or flat-tops. Garnishing means weaving the net so as to make it less transparent (fig. 79). Use the nets so that they conceal the *shape* of your vehicle, gun, or shelter, and so that no betraying *shadow* is cast (fig. 80).

b. There are many kinds of artificial camouflage materials and many ways to use them. As you learn about them in training take note of details which will make your camouflage successful.

① Wrong. Scouts are silhouetted against sky.

② Right. Scouts in shadows with dark foliage as background.

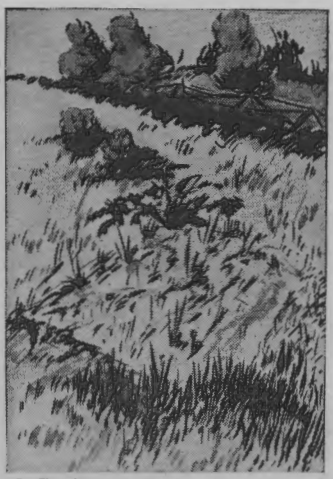
FIGURE 75.—Use shadow and terrain in observing.

① Wrong. No camouflage. Gun and gunners conspicuous.

② Right. Twigs, leaves, branches used to blend emplacement against background.

FIGURE 76.—Use natural materials for camouflage.

① Uncamouflaged.



② Spoil carefully disposed of. Fox hole covered with shrubs and grass.

FIGURE 77.—How to use natural materials to conceal fox holes.

① Wrong.

② Right.

FIGURE 78.—Camouflage your tent with natural materials. Note characteristic black telltale triangular shadow of uncamouflaged tents on left.

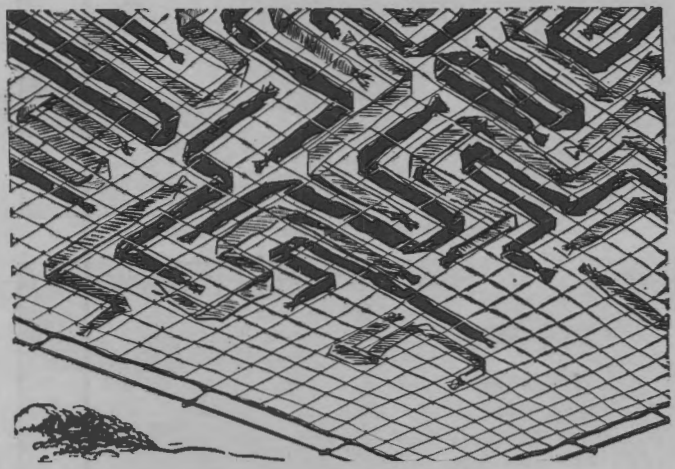
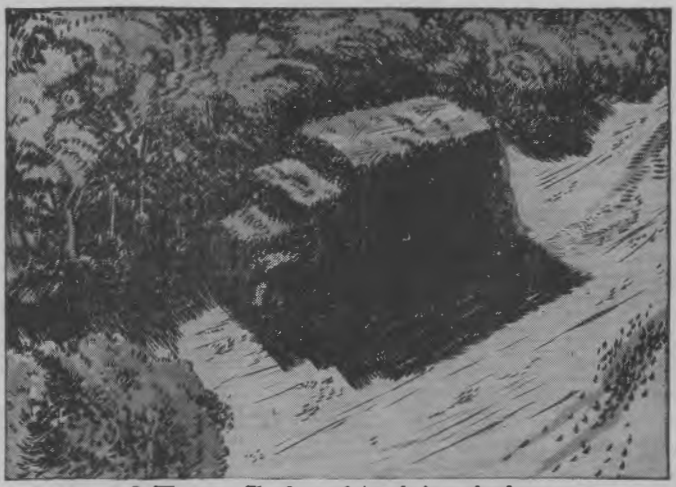
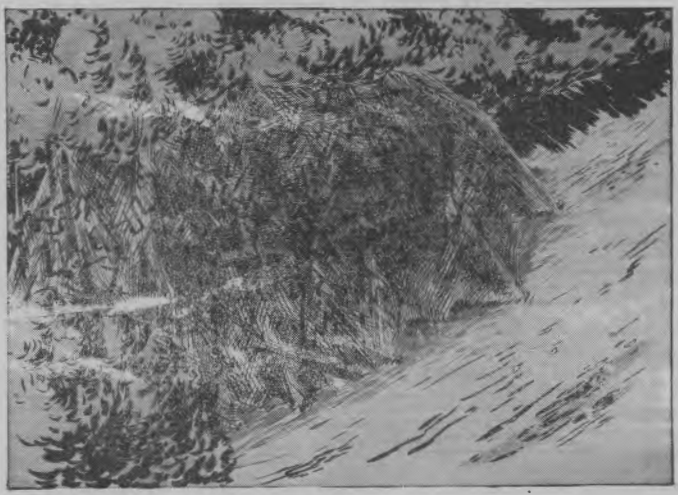


FIGURE 79.—Detail of garnished net.



① Wrong. Shadow of truck is unbroken.



② Right. Shadow is broken up and truck is concealed.

FIGURE 80.—Use of camouflage net on vehicles.

CHAPTER 6

EXPLOSIVES AND DEMOLITIONS

■ 45. THE JOB OF DESTRUCTION.—*a.* As an engineer soldier, one of your most important jobs is the handling of explosives and demolition tools. It takes training to become an expert demolition man. There is a great deal to learn. In this chapter you will find enough fundamentals to give you a good start. With these essentials and with experience you can gradually become an expert.

b. You must learn this job thoroughly. It is a great responsibility. When you are given the job of blowing up a bridge, a road, or a building, that bridge, or road, or building *must be destroyed at the specified time.* There can be no mistakes. Demolitions are usually ordered at critical times; and the failure of a single demolition may cost the lives of hundreds of men. You must not fail.

■ 46. EQUIPMENT.—Demolition sets are issued to all general engineer units and many special engineer units. Each set includes a supply of explosives and the necessary tools and equipment for preparing, priming, and firing demolition charges. Earth-drilling tools, wood augers, and rock drills required for placing charges are available in pioneer and carpenter sets.

■ 47. EXPLOSIVES.—*a. TNT.*—(1) TNT (trinitrotoluene) is the standard explosive for Army use. It is issued in ½-pound blocks encased in a cardboard container closed at both ends with lacquered tin (fig. 81). One end of each block has a cylindrical hole, approximately 5/16 inch in diameter and 2⅛ inches long, for receiving the cap.

(2) TNT is one of the safest explosives to handle, if you know how to use it. It is insensitive to shock and will not detonate even under strong pressure or severe blows. It requires the special issue cap or detonating cord to set it

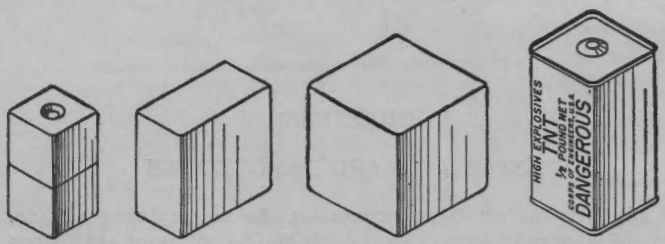


FIGURE 81.—Packages of nitrostarch, and TNT; ¼-, ½-, and 1-pound packages of nitrostarch, and ½-pound block of TNT.

off. In small quantities it can be burned without danger of detonation, but in large quantities the heat generated will raise the temperature to the detonating point. TNT will not dissolve in water and hence is suitable for underwater demolition work.

b. Nitrostarch.—Nitrostarch is issued in ½-pound, cardboard-covered blocks of the same size and shape as TNT, and in 1-pound paper-wrapped packages. Each of the 1-pound packages is made up of four ¼-pound packages, which, in turn, are made up of three 1/12-pound blocks. Each of these blocks has a cap hole extending all the way through it. Nitrostarch is similar in many respects to TNT.

c. Dynamite.—Dynamite is issued in approximately ½-pound sticks, approximately 1¼ inches in diameter and 8 inches in length. Fifty percent straight dynamite is equal in strength (pound for pound) to TNT. It is much more sensitive than TNT and may be detonated by a blow with a metal instrument, or by flying sparks struck from metal striking metal. When frozen it is especially dangerous and must be handled with extreme care.

d. Ammonium nitrate cratering explosive (fig. 94).—Ammonium nitrate cratering explosive is issued in 40-pound charges, each packed in a cylindrical container of tin or other moistureproof material of equal strength. The metal container is about 8¼ inches in diameter and 17 inches in height; another type of container, made of waterproofed cardboard, is 7 inches in diameter and about 21 inches high. Two tubes are secured to the outside wall of each container,

one for receiving the detonating cord, and the other the special cap. If exposed to air, ammonium nitrate explosive absorbs moisture rapidly; consequently, it must never be removed from the container. It is used principally in making crater obstacles for tanks and other motorized vehicles.

■ 48. BANGALORE TORPEDO.—*a.* The bangalore torpedo is a metal tube or pipe filled with explosives. Its primary uses are to cut gaps in barbed wire obstacles and to cause detonation of mines. The standard bangalore torpedo, about 2 inches in diameter, is issued in 5-foot watertight sections already filled with explosives. Sleeves are provided for connecting sections to extend torpedoes to any desired length. By fastening the rounded nose on the forward end, you can push the torpedo through a band of barbed wire without getting it caught on the wires.

b. To explode the torpedo, an electric or nonelectric cap, or primacord, is inserted in the cap well in the trailing end of the torpedo. When several sections are joined to form a long torpedo, it is necessary to place a cap only in the last section, since detonation of one section will cause the whole torpedo to explode. If standard-type torpedoes are not available, you can make bangalore torpedoes by filling a pipe (for example, a 2-inch water pipe or an old drain pipe) with explosives; the ends are closed with wooden plugs, and one end is primed by making a hole through one of the plugs; a primer made with TNT block and primacord is placed inside the torpedo and the primacord end is drawn through the hole in the wooden block.

c. Remember that each 5-foot section of the bangalore torpedo is loaded with about 10 pounds of high explosive, and the same precautions in handling and firing must be taken as when other military high explosives are used.

■ 49. FIRING MATERIALS.—*a. Caps* (figs. 82 and 83).—Caps are placed in charges to set them off. Standard commercial caps will not detonate TNT or ammonium nitrate cratering charge; therefore the army has adopted a special cap. Caps are classified as electric or nonelectric, depending on whether they are set off by electricity or fuze. Both types must be

handled with great care, because they may be set off by dropping or hitting them, or exposing them to excessive heat.

b. Exploders.—Exploders are used to supply electric current to set off electric caps. The 10-cap exploder is operated by a quick twist of the handle. The 30-cap exploder is operated by slowly pulling the handle all the way up and then pushing it all the way down as fast and as hard as possible.

c. Firing wire.—Firing wire, carried on a metal reel, is used to connect the exploder to wires of electric caps placed in charges. It is issued in 500-foot lengths so that a man may fire the charge from a safe distance. Cap wires are connected to the free end of the firing wire, and the exploder is connected to the end which is fixed to the metal reel. When extremely large charges or steel-cutting charges are being fired, two or more reels of wire may be connected so as to enable the firer to fire the charge from a distance of 1,000 feet or more.

d. Time fuze.—A time fuze is used to set off nonelectric caps. It consists of a train of black powder contained in a waterproofed textile covering which may be either white or orange. When using a time fuze, cut it to the desired length and crimp one end in the nonelectric cap. Light the other end with a match or fuze lighter after the explosive charge has been prepared. Always be sure to use a fuze long enough to enable you to reach a place of safety before the charge explodes. A time fuze burns at the rate of about 2 feet per minute.

e. Fuze lighter.—The fuze lighter (fig. 84) is used to light a time fuze. The open end is placed over the end of the time fuze where it is held in place by means of teeth inside the fuze lighter. These teeth permit the fuze to enter, but are inclined so as to bind the fuze and prevent its removal. It is unnecessary to crimp the lighter. Pulling the handle causes a flame inside the lighter which lights the fuze even in wet or windy weather, if the lighter and the powder train in the fuze *have been kept dry.* The fuze lighter should be set off by means of a steady pull (*not a jerk*). (Fig. 100 shows how to improvise a fuze lighter.)

f. Detonating cord.—A detonating cord consists of a train

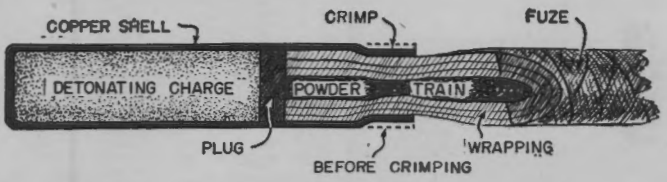


FIGURE 82.—Nonelectric cap.

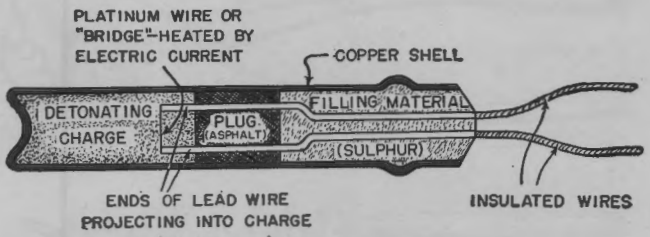


FIGURE 83.—Electric cap.

of high explosive contained in a waterproofed textile covering. It is set off by a cap taped or tied to it. Instead of burning like a time fuze, it explodes like other high explosives and will set off other explosives properly connected to it. It is used mainly to set off a number of charges at one time or to fire a charge in a deep hole. Its action is instantaneous; therefore, whether the detonating cord is fired by an electric or nonelectric cap, the firer should take the same precautions as if the cap were placed directly in the charge.

g. Crimper.—The crimper (fig. 85) is used to crimp the open end of the nonelectric cap around the time fuze and to cut time fuze. One leg of the handle is pointed for use in making holes for caps in dynamite, and the other leg has a screw-driver end.

h. Tools for boring holes.—Holes in earth, concrete, rock, or other material in which explosive charges may be placed are made with many kinds of hand and power tools. Miners' tools are shown in figures 86, 87, and 88. Tools other than those shown here include the air compressor, with its rock and pavement-breaking attachments (see figs. 30 and 31), and two types of earth auger, one of which drills holes 6

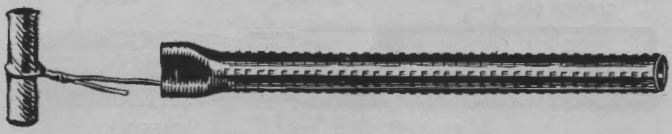


FIGURE 84.—Fuze lighter.

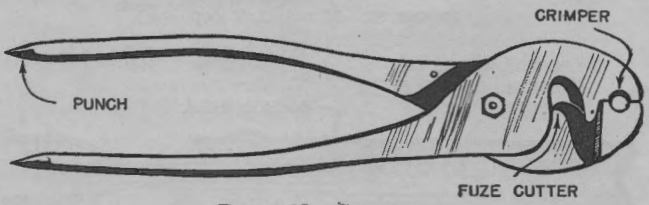


FIGURE 85.—Crimper.

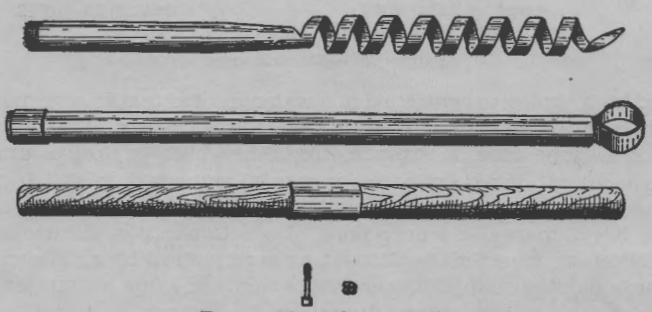


FIGURE 86.—Mining drill.

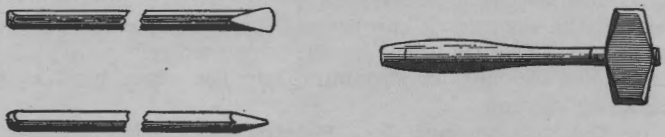


FIGURE 87.—Hand rock drill and hammer.

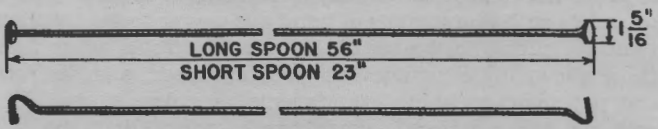


FIGURE 88.—Miners' spoons.

inches in diameter and the other holes 10 inches in diameter. (See fig. 17.) These augers are useful in drilling holes to place charges for road craters.

■ 50. PRIMERS.—A primer is a block or package of high explosive with a cap placed in it, or detonating cord tied through or around it. A charge is primed by placing in it a primer prepared as above. The purpose of the primer is to insure detonation of charge. The cap or detonating cord sets off the block or stick of explosive in which it is placed, which in turn sets off the remainder of the charge.

a. Primer of TNT or dynamite, with nonelectric cap and fuze.—Cut fuze off *square* with fuze cutter. See that no dirt is in the open end of the cap, then slip it over the fuze as far down as it will go. Hold the fuze in one hand and crimp cap to fuze with cap crimper, making crimp near open end of cap. Next, put cap with fuze attached into the hole in TNT block or dynamite stick (figs. 89, 90, and 91). The twine holding the cap in place must be tied so that when the fuze is pulled, the twine takes the pull and the cap is not moved in the hole.

b. Primer of TNT block or dynamite, with electric cap.—Place cap in hole in TNT block, making a clove hitch in the cap end of the lead wires. Pass this loop around TNT block and pull tight, leaving the wire slack from the loop to the cap. The same procedure is used with a dynamite stick (see fig. 92); another method is to tie a preliminary half hitch near the bottom of the stick before tying the clove hitch near the top.

c. Primer with detonating cord and TNT block.—Tie cord directly to the TNT block as shown in figure 93. To do this, tie one-half of a clove hitch, take one full turn around the block, then tie the second half of the clove hitch. Pull all three turns tight so they will fit *snugly against each other and against the block.*

d. Primer with ammonium nitrate cratering charge.—For electrical firing place an electric cap in the cap well provided on the side of the container. Make several turns with the lead wires around the knob above the cap well and pull tight, so that a pull on the lead wires will not dislodge the

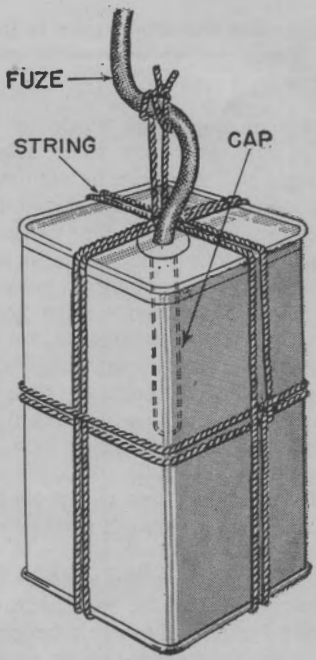


FIGURE 89.—Primer made of TNT block and nonelectric cap.

cap (fig. 94). To make a primer using detonating cord, pass the detonating cord all the way through the tunnel (from top to bottom) on the side of the container and tie an overhand knot in the lower end to prevent the cord from pulling out of the tunnel. Both means of detonating should be used simultaneously. Do not use detonating cord or electric-cap leads to lower the ammonium nitrate cratering charges into holes; use a cord attached to the ring in the top of the charge.

■ 51. DETONATING ASSEMBLY.—Detonating assemblies may be prepared prior to an operation so that the detonating device may be quickly attached to an emplaced charge such as a crater explosive or a bangalore torpedo. The assembly is

FIGURE 90.—Primer made with nonelectric cap in end of dynamite stick.

made by binding a nonelectric cap to a piece of detonating cord (as shown in fig. 96), allowing sufficient length of detonating cord to tie a square-knot splice to the charge. Time fuze is crimped to the cap, and a fuze lighter is crimped to the other end of the fuze. (See fig. 95.)

■ 52. NONELECTRIC CONNECTIONS.—*a. To attach cap (electric or nonelectric) to detonating cord.*—Lay the cap and time fuze alongside the detonating cord, with the cap pointing in the direction of the charge. Bind the cap and detonating cord securely together, using either friction tape or twine, as shown in figure 96.

b. To splice detonating cord.—Use a square knot to tie two ends of detonating cord together. The loop in the end of each piece of detonating cord must be at least 6 inches long (fig. 97).

c. To connect a branch line of detonating cord to a main line.—Use two half hitches to tie a branch line to a detonat-

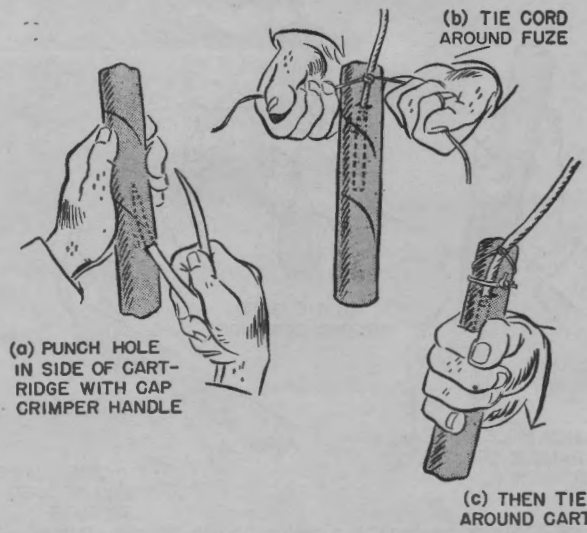


FIGURE 91.—Primer made with nonelectric cap in side of dynamite stick.

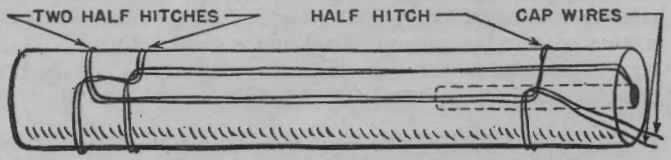
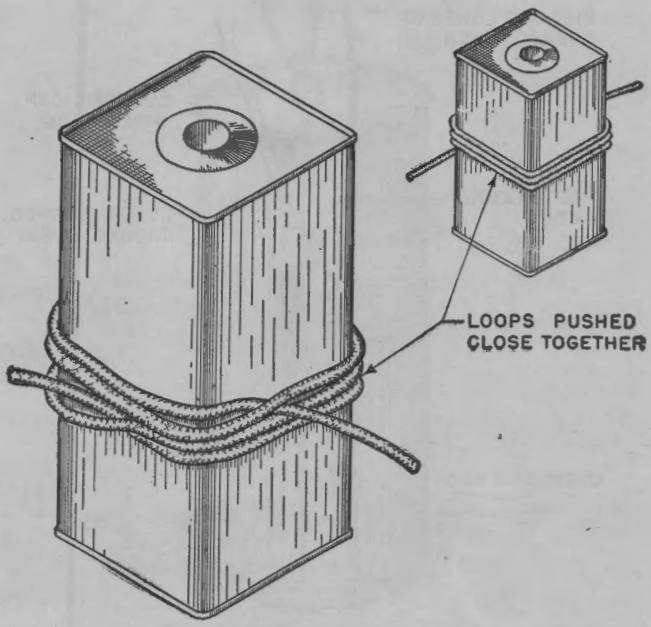


FIGURE 92.—Primer made with electric cap and dynamite stick.

ing-cord main line. Make sure that the branch line leaves the main line at an angle of 90°. Leave 6 inches of the running end of the branch line free beyond the tie (fig. 98).

d. Time-fuze connections.—Figure 99 shows how to splice two pieces of time fuze. Make sure the powder train is continuous.

e. Improvising fuze lighter.—To make a fuze lighter when the standard lighter is unavailable, slit the fuze and insert



1. Make one-half of clove hitch.
2. Take one complete turn around block.
3. Make second half of clove hitch.
4. Pull cord *tight*, pushing strands together.
5. Cord should fit snugly against block and three complete loops around block should be in contact as much as possible.

FIGURE 93.—Fastening detonating cord to TNT block.

the head of a match. Keep the match head in contact with the powder train, but allow a bit of the head to protrude. The abrasive side of a match box rubbed against the match will ignite the fuze (fig. 100).

■ 53. ELECTRIC CONNECTIONS.—*a.* Cap wires are insulated by a coating of varnish on the wires and fabric cover. Figures 101 and 102 show how to make splices with electric wires.

b. Testing a circuit.—(1) To test a circuit use a galvanometer. The firing wire should be tested before it is connected

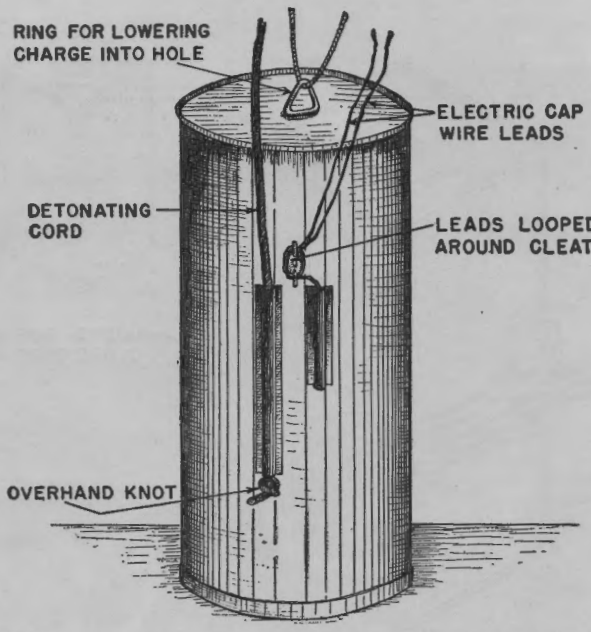


FIGURE 94.—Ammonium nitrate cratering charge with electric-cap and detonating-cord primers.

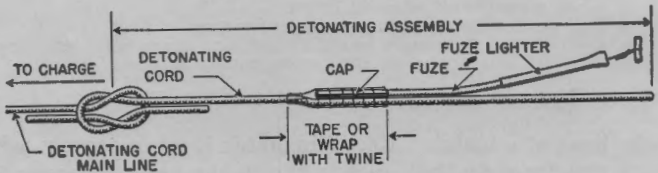


FIGURE 95.—Detonating assembly.

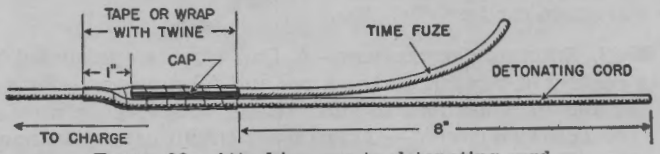


FIGURE 96.—Attaching cap to detonating cord.

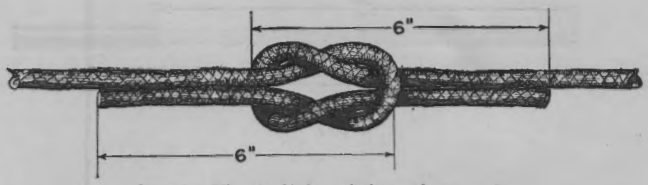


FIGURE 97.—Splicing detonating cord.

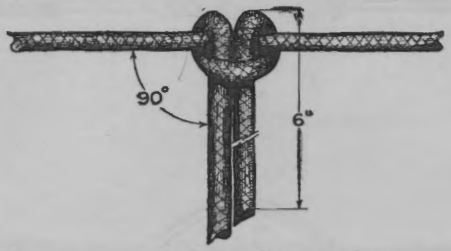


FIGURE 98.—Attaching branch line of detonating cord to main line.

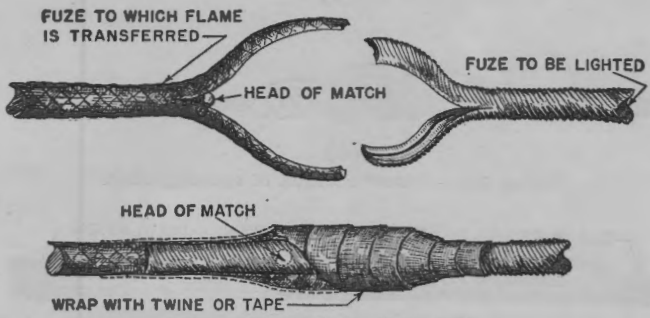


FIGURE 99.—Splicing time fuze.

FIGURE 100.—Fuze lighter made with match.

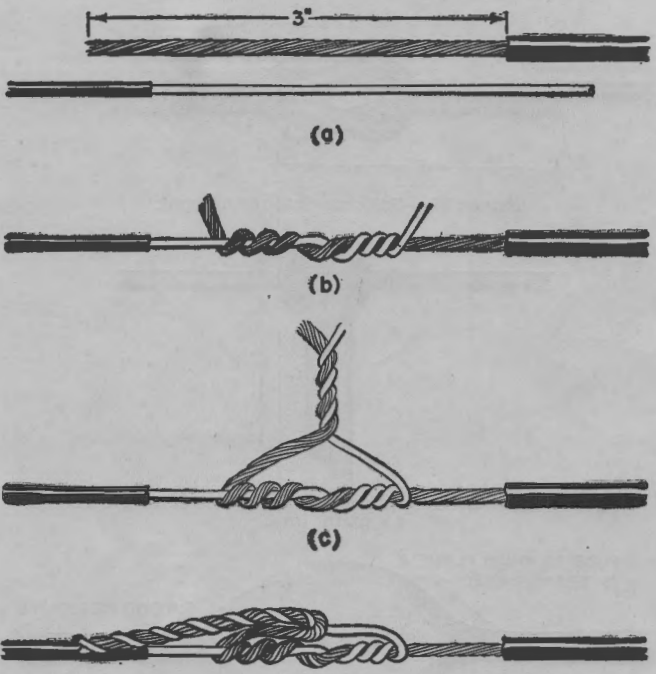


FIGURE 101.—Correct method of splicing wires.

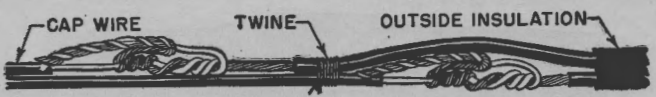


FIGURE 102.—Staggered joint for connecting cap wires to lead wires.

to the cap wires to insure that it is neither shortcircuited nor broken. To do this, separate the two wires at the free end of the reel, and touch the exploder ends of the wires to the galvanometer posts. The galvanometer needle should not move; if it does, it indicates a short circuit which must

be repaired before the firing wire can be used. Next, twist the two free ends of the firing wire together. Then touch the exploder ends of the wire to the galvanometer posts. This should cause full-scale deflection of the needle. If it does not, it indicates a break or a point of high resistance, which must be repaired.

(2) After the firing wire has been tested (and repaired, if necessary) connect the free ends of the firing wire to the cap wires. Again touch the exploder ends of the firing wire to the galvanometer posts. If the needle moves along the scale, it indicates that the circuit is ready for firing if due care has been exercised to insure against shortcircuiting the cap wires while placing the charges. If the needle does not move, there is a break in the cap-wire circuit. If the needle moves only slightly, there is a place of high resistance, such as a bad joint, in the cap-wire circuit. If the caps are placed in parallel, each cap must be tested separately. Each series in a parallel series circuit must also be tested separately.

■ 54. PLACING CHARGES.—The officer, or noncommissioned officer, in charge of each demolition project gives definite instructions as to the sizes of charges to be used and where and how they are to be placed. Failure to use the proper amount of explosive results in failure of the demolition project, and placing a charge incorrectly may be just as disastrous. Don't try to save yourself work by using a smaller charge or by placing the charge in a location that is easier to get to than the location directed. If, for any reason, it is impossible to place the charge in the location or manner directed, report this fact to the officer or noncommissioned officer in charge. The following points will be helpful in enabling you to place charges properly to attack concrete, steel, and timber.

a. Crater.—Figure 103 illustrates how to prepare a borehole to blow a crater with TNT. The depth of the hole is determined by the officer in charge. In place of the TNT blocks, one or more ammonium nitrate cratering charges may be used.

b. Concrete.—Because of the difficulty of placing internal charges, concrete is normally attacked by external charges

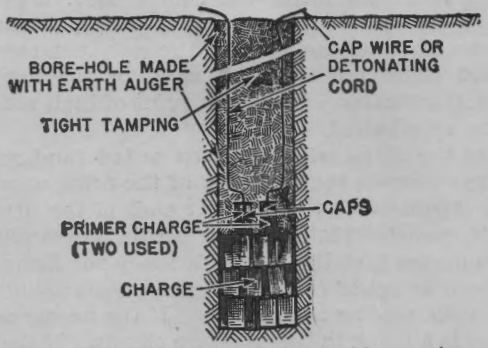


FIGURE 103.—Bore hole loaded to blow crater.

calculated to blast through its entire thickness. In attacking a concrete wall, or a bridge abutment or pier, the entire amount of explosive is normally concentrated at the midpoint of the structure, if the width is not more than twice the thickness. Where the width is more than twice the thickness, two or more charges are used, each charge being large enough to shatter the thickness of the wall, and the distance between successive charges being not greater than twice the thickness of the structure.

c. Steel.—The effects of an explosion are very localized in steel. Only that portion of steel which is in close contact with the explosive charge is cut. A concentrated charge placed on a steel plate will simply blow a hole in the plate or dent it directly under the charge. Therefore, if it is desired to cut a steel plate, the explosive charge must be distributed over the entire line along which the cut is desired. Likewise in cutting steel I-beams, built-up girders, columns, etc., the charge must be distributed so that the entire cross section of the member will be cut. (See fig. 104.) Charges must never be placed directly opposite one another on opposite sides of a steel plate or members. When charges must be placed on opposite sides they should be 3 inches apart along the member.

d. Timber.—External charges for cutting trees, round timbers, etc., are placed around one side of the object (fig. 105).

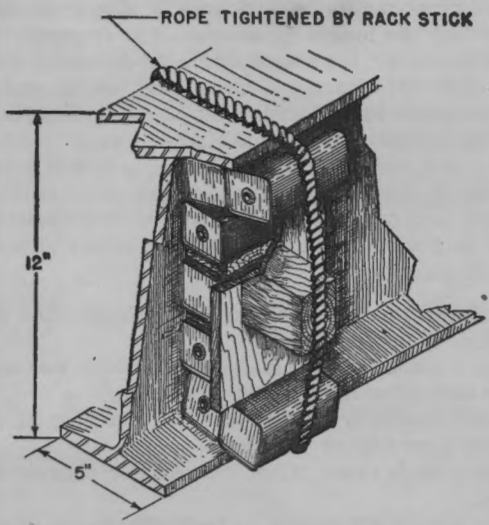
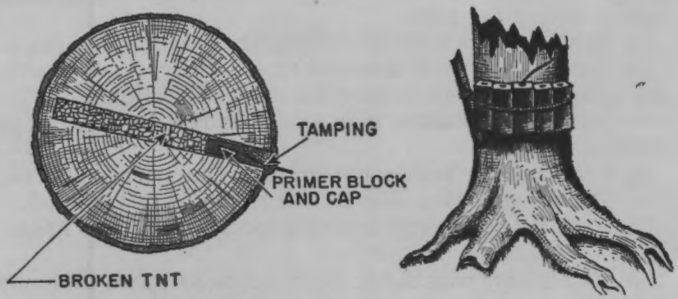


FIGURE 104.—How to blow 12-inch I-beam. Note location of TNT blocks.



① Internal charge. ② External charge.

FIGURE 105.—How to blow round timber.

The charge should not extend more than halfway around the object being cut. External charges for cutting square timber members are placed on one face along the line of the desired cut. In the case of rectangular timbers not having

a square cross section, the charge is placed on one of the faces having the longer dimension. For example, to cut 10- by 12-inch timber, the charge is placed on one of the 12-inch faces. Internal charges require only about one-sixth as much explosive to cut timber as external charges. Hence, when time permits, an internal charge is used. Such a charge is placed in a bore hole in the timber, and well tamped with moist clay or mud. An underwater charge for cutting a timber pile is fastened to a board, then shoved beneath the water surface in close contact with the pile, where it is lashed or nailed in place.

■ 55. SAFETY PRECAUTIONS.—*a*. Don't forget that explosives are *always* dangerous.

b. Don't smoke while handling explosives, nor handle explosives near open lights, fires, or stoves.

c. Don't handle or keep explosives in or near places where there are large groups of people.

d. Don't open cases of explosives near caps or other explosives.

e. Don't leave explosives in the open where they may be stolen, tripped over, or where animals can get at them.

f. Don't leave explosives in wet or damp places; keep them locked up in a dry place.

g. Don't use frozen, chilled, or bleeding (leaking) dynamite.

h. Don't try to thaw dynamite; have an expert do it with the proper equipment or get some other explosive.

i. Don't put dynamite near steam or hot water pipes or stoves.

j. Don't keep or transport caps anywhere near explosives.

k. Don't drop or tap caps or carry them in your pocket.

l. Don't take caps from box with wires or nails; use fingers only.

m. Don't leave caps out in the sunlight, or where they may be stepped on or run over. Keep them in their box until time to use them.

n. Don't pull on wires of an electric cap.

o. Don't hold caps in hand while crimping; place cap on one end of fuze and hold fuze end.

p. Don't crimp cap with anything except issue cap-crimper.

q. Don't tamp with iron or steel bars or tools. Use only blunt wooden tamping stick and tamp lightly at first, then harder.

r. Don't force primer into a drill hole; make hole big enough.

s. Don't cut fuze too short; explosion may occur before safe distance can be gained.

t. Don't risk misfire by using too weak cap; employ proper cap for explosive used. You must use special issue cap to detonate TNT.

u. Don't explode charge until everyone is safely under cover or out of danger.

v. Don't connect firing wires to exploder until ready to fire charge.

w. Don't spring (enlarge) bore hole and then immediately reload; the bore hole will still be hot and may explode charge.

x. If charge fails to explode, wait at least 30 minutes before investigating it, unless an officer or experienced demolitions man directs otherwise. Explode misfired charge by means of another charge placed as close as possible to misfire. The old charge should not be disturbed.

CHAPTER 7

ENGINEERS AND TANKS

Paragraphs
SECTION I. Tank hunting 56–59
II. Antitank defense 60–61

SECTION I

TANK HUNTING

■ 56. THE ADVANTAGES ARE WITH THE HUNTER.—The big game sometimes hunted by engineers are tanks. Like any other kind of big game hunting, such as elephant hunting or lion hunting, the advantages are with the hunter; he almost always is the winner; but there is enough danger in the sport to keep the hunter on his toes. With courage and determination the engineer can use his weapons to hunt down and destroy 80,000 pounds of fighting steel.

■ 57. TANK WEAKNESSES.—Tanks have a number of weak points and any one of these may be used for its annihilation. Here are some things to remember:

a. A tank is big—a large target.

b. A tank is run by a mechanism which is breakable.

c. A tank is armored, but there is a limit to its armor and our weapons are capable of piercing the heaviest armor.

d. Tanks can't go everywhere. They can't climb steep banks, hurdle special obstacles, ford deep streams, or go through thick forests.

e. Tanks are partly blind. They can't see as well as you can.

f. They can't go over a mine undamaged.

g. They are run by human beings—men as vulnerable to fire, lead, steel, heat, and explosives as a man out of a tank.

h. Tanks are noisy; they can't "sneak up" on you, and they can't hear most noises.

■ 58. ANTITANK WEAPONS.—The weapons of the engineer tank hunter are simple to use, but deadly in their effect. Some of the weapons used are—

a. Antitank gun, 37-mm (see fig. 66).—The 37-mm gun is a high-velocity weapon. Its armor-piercing ammunition penetrates all but the largest tanks. It is extremely accurate and maneuverable.

b. Antitank grenade.—Antitank grenades (M9) are fired from an M1903 rifle. These explosive charges have a short range (75 yards), but they do terrific damage to a tank. They are easily transported, and individual soldiers can destroy a tank with them.

c. Antitank rocket.—The antitank rocket is a new weapon—our Army's destructive answer to the tank. In the hands of the soldier, it is a powerful tank-destroying instrument, accurate up to 300 yards.

d. Frangible grenades ("Molotov cocktails") (see fig. 106).—These are incendiary grenades or improvised bottled inflammable liquid mixed with sawdust. A number of them thrown at the upper part of a tank and ignited will set the tank on fire.

e. Mines (fig. 107).—Antitank mines stop a tank and allow antitank fire to be brought upon it.

■ 59. THE HUNT.—Tank hunting follows a simple pattern, varied according to whether it is day or night.

a. Daytime hunt.—The daytime technique consists of setting a trap in a tank defile. A tank defile is a route which forces a tank to adhere to a certain path: for example, a road cut into a hill and surrounded by steep cliffs, or a road passing through an otherwise impassable bog. By means of mines the tank is confined in a limited space, and the hunters destroy it with their weapons. Smoke is used to conceal the activity of the hunters once the tank is trapped. (See fig. 106.)

b. Nighttime hunt.—At night tank crews rest themselves and their tanks. The usual procedure is for the crews to get out of the tanks and rest in the immediate vicinity, posting sentinels to guard against attack. By means of stealth, such tank bivouacs can be attacked successfully.

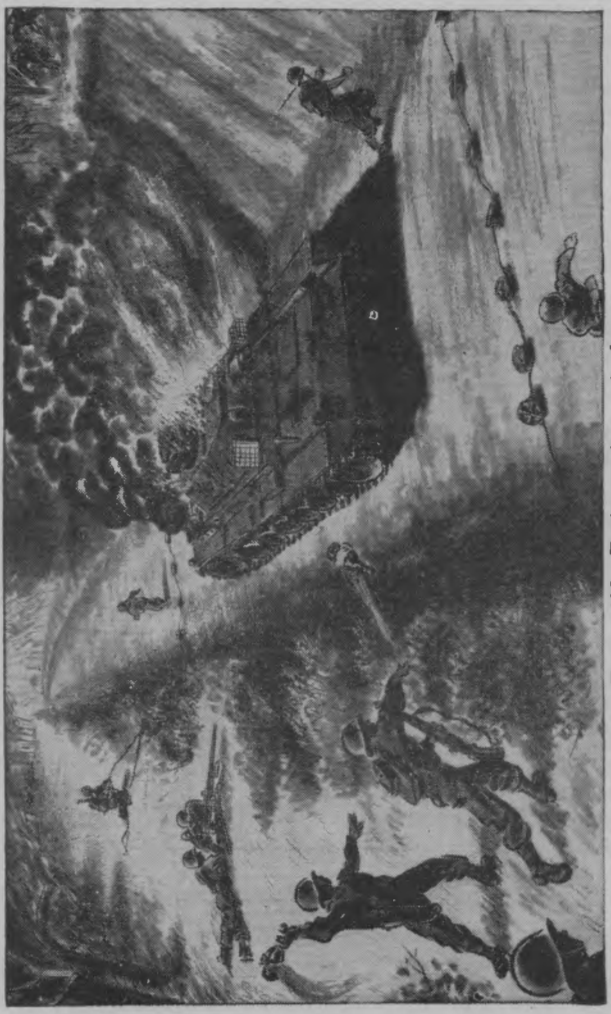
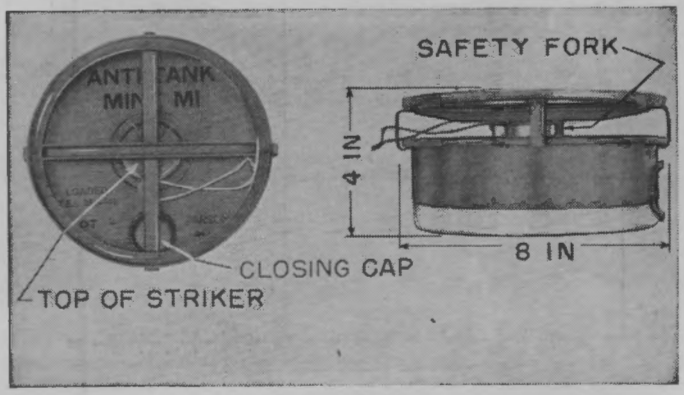


FIGURE 106.—Engineers trap a tank.

① Disassembled.



② Assembled.

FIGURE 107.—Antitank mine.

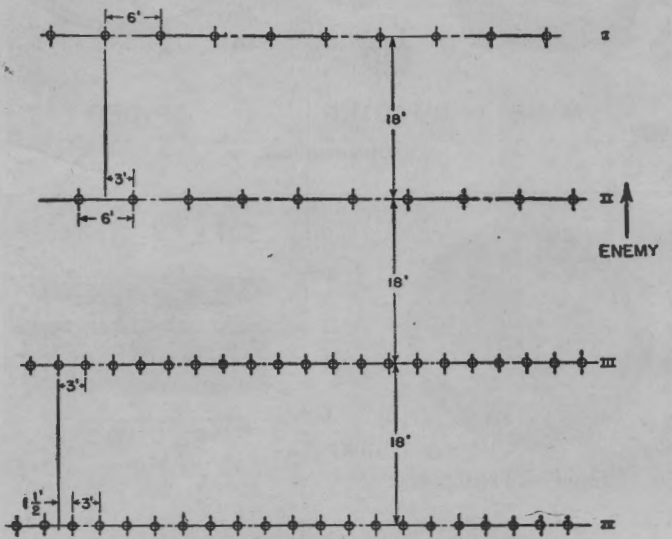
Part of the attacking party is detailed to take care of the crew members, while another party is assigned to destroy the tanks with hand-placed charges.

SECTION II

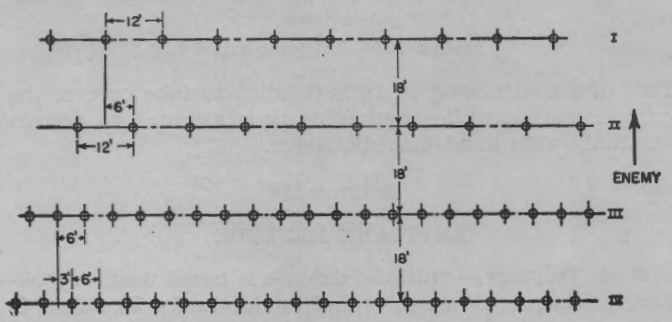
ANTITANK DEFENSE

■ **60. SECURITY.**—Antitank defense is based upon two objectives: to *prevent surprise* and to *stop tanks, by means of obstacles, long enough to destroy them with antitank fire.* To accomplish the first of these objectives a constant sys-

tem of sentinels is maintained; to accomplish the second a well-integrated system of obstacles, always defended by antitank and small-arms fire, is used. The small-arms fire prevents the removal of the obstacles by enemy engineers.



① Road-block mine field.



② Hasty mine field.

FIGURE 108.—Mine-field patterns.

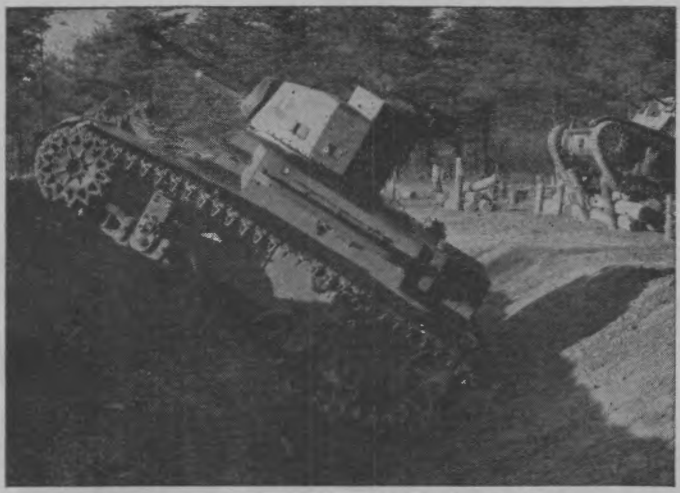


FIGURE 109.—Tank stopped by antitank ditch.

FIGURE 110.—Tank stopped by log wall.

■ 61. OBSTACLES.—*a. Mine fields.*—Mine fields are laid in definite patterns, two of which are shown in figure 108. Patterns are designed to do two things:

(1) Stop the tank before it gets through the field.

(2) Make it easier for our own engineers to remove the field later on.

The details of mine-field laying are taken up in FM 5–30.

b. Ditches.—Antitank ditches have sides steep enough to stop a tank. (See fig. 109.)

c. Posts and logs.—Post and log obstacles are effective in stopping or "bellying up" a tank. (See fig. 110.)

d. Abatis.—A road block made with fallen trees can stop a tank for a time, if the trees are big enough. (See fig. 111.)

FIGURE 111.—Abatis constructed of interlaced trees in defile.

CHAPTER 8

ASSAULT OF A FORTIFIED POSITION

■ 62. THE PROBLEM.—*a.* A typical prepared defensive system of fortifications consists of a number of mutually supporting strong points, such as concrete emplacements called "pillboxes." The best way many of these can be destroyed is by foot troops armed with special weapons. It's a difficult combined-arms job to which engineers are often assigned. It requires aggressiveness, skill, speed, teamwork, courage, and determination. This chapter outlines procedure for a simple assault on a single fortified emplacement containing men and guns which fire from loopholes or embrasures. However, it must be remembered that pillboxes in an area are sited for mutual support; the whole problem is more complicated than this one.

b. The fortification is in a strong position. It is well placed; its walls resist bombardment; it generally has an open area around it so that its guns can cover a lot of ground. But, as the attacker, you have a number of important advantages:

(1) You are free to move around in the area, while the emplacement is stationary.

(2) The emplacement has blind spots, especially once you are close to it. It can fire only out of its loopholes.

(3) Once you get near it, the emplacement can't fire at you.

■ 63. PREPARATION.—Much training is required to assault a fortified position, and the teamwork is carefully planned. Each individual in the attacking force has a definite job to do at a certain time. He must accomplish his task, or the efforts of the whole force may fail.

■ 64. ORGANIZATION.—A typical assault echelon for the attack of an emplacement is composed of two platoons—an assault

platoon and an infantry rifle platoon. The infantry platoon attacks and neutralizes the earthen entrenchments and emplacements which are near the fortified emplacement and which cover the fortified emplacement with their fire. The assault platoon, which may include engineers, has two sections: the *assault detachment* and the *support*. It is this assault detachment which finally reaches and destroys the pillbox.

■ 65. ATTACK.—The attack proceeds, generally, in the following steps:

a. Artillery and airplanes bombard emplacement.

b. Direct-fire weapons fire at embrasures.

c. A special detachment breaches bands of obstacles to prepare way for assault echelon.

d. Assault echelon attacks.

■ 66. ASSAULT PLATOON.—*a.* The assault platoon works on a simple plan: one part of the assault platoon "covers" the advance of the second part until the fort is reached and the guns can be silenced by hand-placed charges. The covering section may consist of men armed with "tommy guns," machine guns, pistols, grenades, and rifles, which are aimed at the gun slits in the emplacement in order to stop the fire of the defenders. The advancing group moves forward in bounds, taking advantage of shell holes and other cover. Smoke is used to cover the advance.

b. The forward element of the assault detachment has two main parts: flamethrowers, who get close to the pillbox and blind its occupants with fire and smoke (see fig. 112); and charge placers, who rush to the fortification and thrust into the weak spots of the fort (doors and embrasure openings) TNT attached to the end of long poles. (See fig. 113.)

c. After one pillbox is silenced the assault group reorganizes and moves on to the next pillbox.

FIGURE 112.—Engineers assaulting a fortified emplacement.

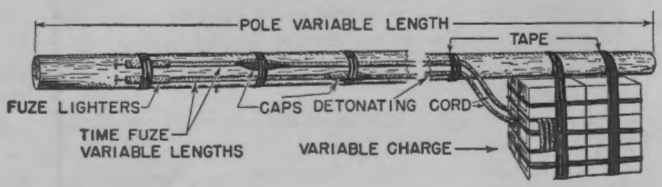


FIGURE 113.—Charge-placing pole, improvised charge.

CHAPTER 9

BRIDGES

■ 67. GENERAL.—An unfordable river is a difficult obstacle to an advancing army. The enemy, therefore, destroys all possible bridges in the path of advance. It is the job of engineers to build substitute bridges in the shortest possible time.

■ 68. SPEED AND TEAMWORK.—Army engineers should be the fastest bridge builders in the world. They can build fixed and floating bridges quickly because of two things:

a. Their equipment is designed for hasty, rugged construction.

b. Their building crews are trained in teamwork and speed.

The second factor depends on the individual engineer soldier. Hundreds of feet of bridge must be built in a few hours under difficult conditions; you will be very tired; sometimes you will be under enemy fire; you may be cold and wet; or hot and dry. But upon you depends so much that you must overcome all handicaps. An army may be waiting for the products of your toil. You must give all you have in you to do the job *on time!*

■ 69. BRIDGE TERMS.—Following are some of the common terms used in bridge construction:

a. Abutment.—Shore support of a bridge.

b. Approach.—Roadway leading to the bridge.

c. Balk.—Stringers, or longitudinal load-carrying members, of floating bridge.

d. Bent.—Built-up intermediate support in bridge (see fig. 115).

e. Bracing.—Supporting members connecting adjacent bents to one another or to ground.

f. Cap.—Top horizontal bearing member of bent.

g. Chess.—Floor planks in floating bridge.

h. End dam.—Plank at abutment of bridge, used to hold earth in place behind abutment. (See fig. 114.)

i. Footing.—Piece of wood used beneath supports to give added bearing surface on ground. (See fig. 114.)

j. Guard rail.—Flimsy rope or wooden fence on outer edges of bridge to guide foot troops and vehicles.

k. Holdfast.—Anchorage on shore to which bridge cables are fastened.

l. Pile.—Vertical member of bridge, driven into river bed. Several of them may be made into a pile bent.

m. Post.—Vertical member of trestle bent.

n. Siderail.—Curbing on bridge.

o. Sill.—Horizontal lower bearing member of trestle bent or other support.

p. Span.—Distance between centers of adjacent supports.

q. Stringer.—Longitudinal weight-supporting member of fixed bridge; it carries bridge floor.

r. Sway bracing.—Diagonal bracing on a single bent.

s. Tread.—Additional wearing surface of bridge, running longitudinally.

t. Trestle.—Built-up support, consisting essentially of vertical and horizontal members usually braced by diagonal members.

■ 70. FIXED BRIDGES.—The most common military fixed bridges are the simple stringer bridge, the trestle-bent bridge, the light portable steel bridge, often called H–10, and the Bailey bridge.

a. The simple stringer bridge is usually short. It consists of three elementary parts: two abutments, a single span of stringers, and a floor. Two types of abutments are used, one for use with soft approach roadways, the other for use with firm roadways. (See fig. 114.) Every engineer soldier should know how to construct a simple stringer bridge. Trestle bridges are merely a succession of simple spans in which the trestles take the place of abutments. Timber stringers are seldom used in spans of over 15 feet or steel stringers in spans of over 25 feet.

b. The *trestle-bent bridge* consists of two or more stringer spans. The supports between the abutments are trestle bents. (See fig. 115.)

c. The *light portable steel bridge* (H–10) (figs. 116 and 117) consists of two trusses (assembled by manpower, in lengths up to 72 feet) supporting a one-track timber deck. The 12-

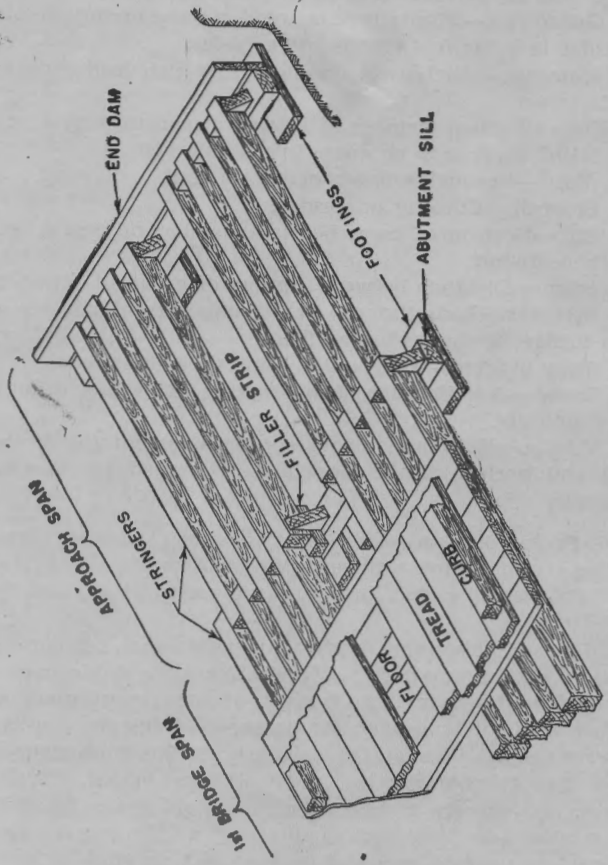


FIGURE 114.—Abutment showing approach span used for soft roadway approach.

foot girder sections are carried in trucks and bolted together to build the bridge. The deck planks are held in place by siderail clamps, which hold the siderails to the trusses.

d. The Bailey bridge is an English panel bridge built to carry heavy loads. It can carry 70 tons on spans up to 120 feet, but requires time for erection for these loads.

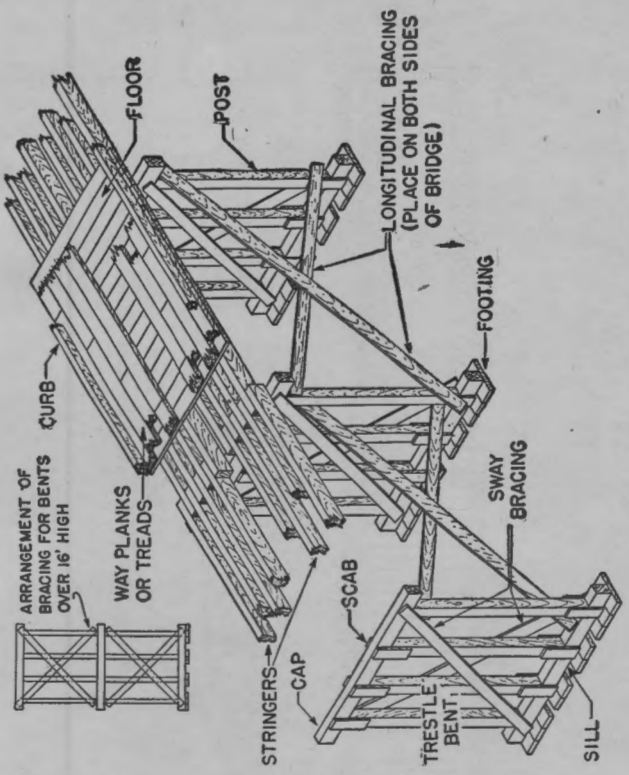


FIGURE 115.—Standard wooden trestle-bent bridge.

■ 71. FLOATING BRIDGES.—There are a number of different kinds of military floating bridges in use. They are carried by different kinds of engineer units.

a. The *footbridge* M1938 is constructed of separate rafts called "bays," each 12 feet long, consisting of a duckboard supported by two floats. (See fig. 118.)

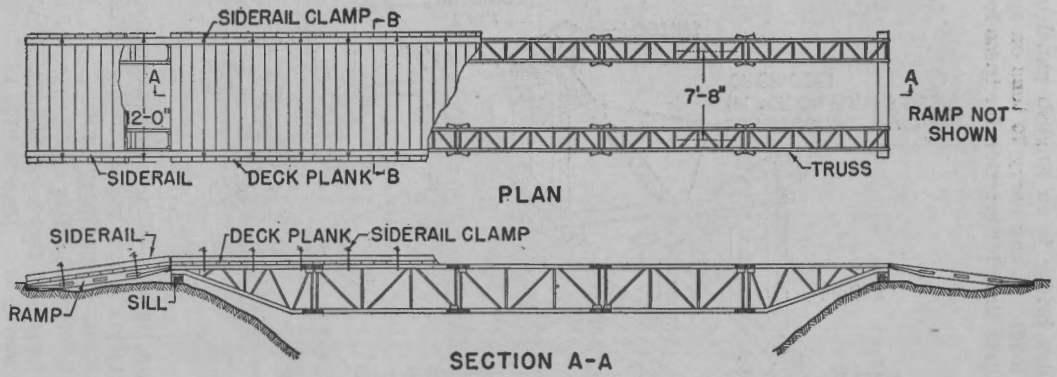


FIGURE 116.—Light portable steel bridge (H–10).

FIGURE 117.—Light portable steel bridge (H–10).

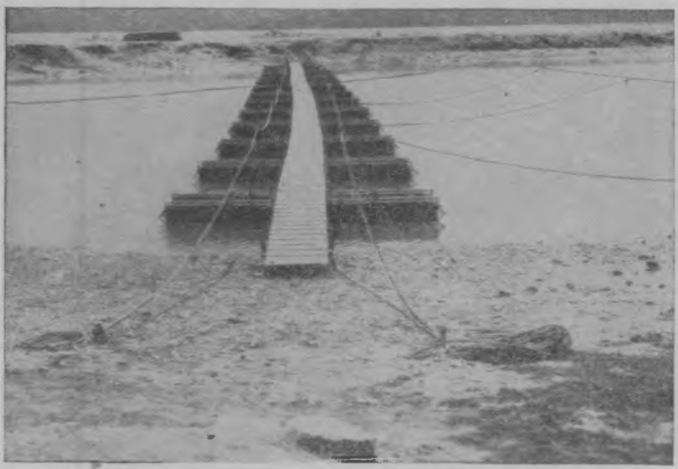


FIGURE 118.—Footbridge M1938.

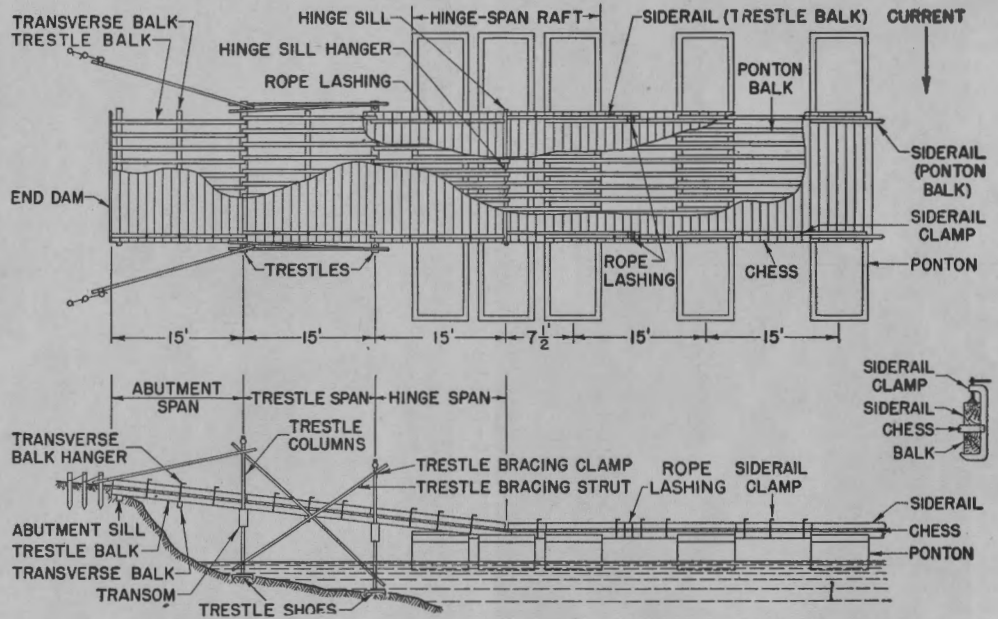


FIGURE 119.—Ponton bridge, 25-ton, showing names of parts.

b. The *light ponton bridge* M1938 is a floating bridge capable of carrying 10-ton traffic in one direction.

c. The *heavy ponton bridge* M1940, 25-ton (see figs. 119 and 120), is similar to the light ponton bridge but is much heavier and will carry 25 tons with normal construction. It can be reinforced to carry 35 tons.

d. The *steel treadway bridge* is designed to carry medium tanks. It has steel treadways for runways, which are emplaced by means of a truck-mounted crane. It uses special rubber pontons. (See fig. 121.)

e. The *pneumatic bridge* M3, made with 12-ton floats, can carry 13 tons, or, when reinforced, 18 tons. It uses regular 10-ton ponton balk and chess for the floor system. (See fig. 122.)

FIGURE 120.—Ponton bridge, 25-ton.

FIGURE 121.—Steel treadway bridge.

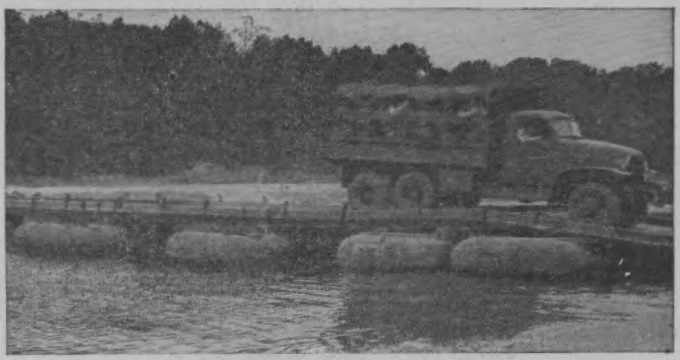


FIGURE 122.—Pneumatic bridge.

CHAPTER 10

BOATS AND RAFTS

■ 72. ENGINEERS IN BOATS.—*a.* Often, before a bridge can be built, part of an army must cross a river by means of boats. It is the job of engineers to supply these boats, to manipulate and paddle them, and to carry other troops, principally infantry, across the stream. Every soldier, and especially every engineer, should be a strong swimmer.

b. Much of the crossing is done at night. Speed, silence, and coordination are demanded. It is up to you to be able to handle your boats in such a manner that the crossing may be made according to plan.

c. With proper training, handling these boats is easy. It requires only one simple rule: *Care.*

■ 73. ASSAULT BOATS.—*a. M1.*—The assault boat M1 (fig. 123) is a 200-pound, flat-bottomed, plywood skiff. It carries 9 infantrymen and their equipment and an engineer crew of 2. It can be carried easily by 4 men.

b. M2.—The assault boat M2 is a 420-pound, blunt-nose scow. It carries 12 infantrymen and a crew of 3 engineers (fig. 124). It is carried by 8 men.

c. Handling.—(1) The boat carriers grasp the boat by means of hand grips on the gunwales. Rifles are slung on the shoulder *away* from the boat. Care must be taken not to drag the bottom on the ground, or to bump the boat against stumps and trees. The boats are usually carried bottom-side up.

(2) The engineer in the stern commands the boat. Paddlers pass their rifles to the men in the boat who are not paddling and kneel on the knee nearest the side. The paddle is grasped just above the blade; the palm of the other hand cups the grip (end of handle). (See fig. 124.) The paddle must enter the water noiselessly at the beginning, and should be held well away from the boat during each

stroke to avoid thumping the side. Speed and silence are essential in making a crossing.

■ 74. PNEUMATIC BOATS.—*a.* Engineers are equipped with a six-man pneumatic reconnaissance boat propelled with paddles (fig. 125). It is inflated by means of the air compressor or by means of a hand pump.

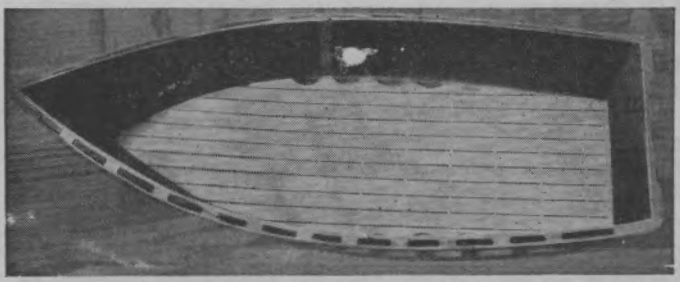
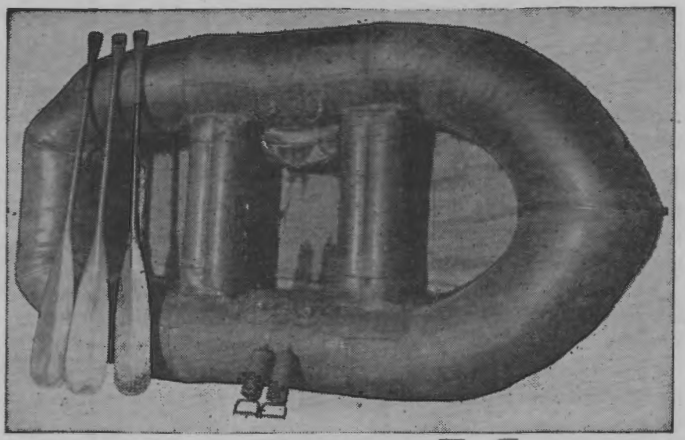


FIGURE 123.—M1 assault boat.

FIGURE 124.—M2 assault boat with 3-man engineer crew and 12 infantrymen with equipment.



① Boat with paddles and pumps.

③ Boat with six-man engineer crew.

FIGURE 125.—Pneumatic reconnaissance boat.

b. The 6-ton and the 12-ton pneumatic floats may be used as boats.

■ 75. STORM BOAT.—The storm boat is a high-powered, flat-bottom, outboard motorboat used in the swift crossing of a wide river.

■ 76. INFANTRY SUPPORT RAFT.—*a.* The principal raft of the engineers is the infantry support raft made out of M2 assault boats. The M2 boats were designed especially so that they may be used for this purpose.

b. The usual three-float raft is made with six M2 boats and six plywood treadways. (Four- and five-float rafts to carry heavier loads can be made.) The sterns of the boats are fastened together in pairs, forminng three floats upon which are placed the treadways. Siderails (curbing) are attached by means of siderail clamps. (See fig.s 126 and 127.)

c. The raft will hold a loaded 2½-ton truck. It is propelled by means of a 22-horsepower motor, or it may be used as a ferry manipulated by ropes.

■ 77. PONTON RAFTS.—*a.* The 10-ton annd 25-ton ponton bridge equipment may be made into rafts propelled by outboard motors.

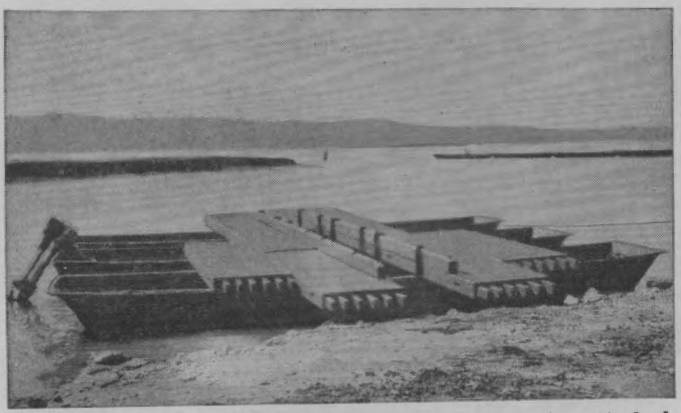


FIGURE 126.—Infantry support raft with outboard motor attached.

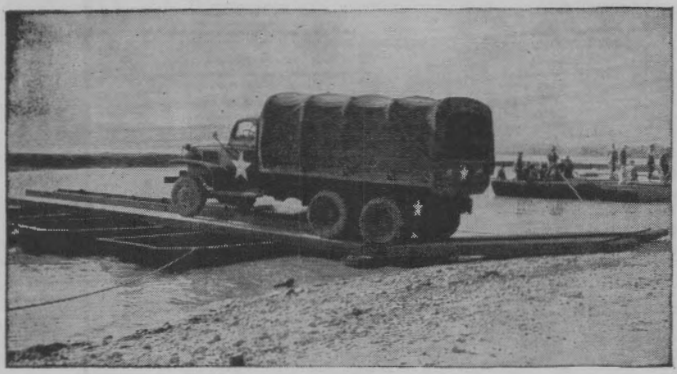


FIGURE 127.—Loading the raft.

CHAPTER 11

AIRDROMES

■ 78. ENGINEERS AND THE FLIERS.—Engineers prepare the way for the Army Air Forces. They are builders, defenders, and maintainers of airfields. Well armed and with much mechanical equipment, aviation engineers plunge into the wildest country, the most forward battle areas, and build swiftly the bases from which our aircraft fight. Once built, these bases must be defended and kept in good condition despite bombing, strafing, or artillery bombardment. The flier depends upon the engineer for this support. *You must not let him down.*

■ 79. DEFINITIONS.—All army engineers should be familiar with the general design, construction, and nomenclature of military airfields, since any general engineer troops may be required to build them. *Airfield* itself is the general term applied to any area used for landing and taking-off of aircraft. Following are some of the more common terms used in connection with airfields.

a. Advanced landing field.—Temporary airfield near front, with only minimum servicing facilities.

b. Air base.—An area including a parent or *base airdrome* and one or more smaller airdromes situated at some distance from parent field. Smaller airdromes are sometimes called *auxiliary* or *satellite* fields. They depend on the base airdrome for complete repair and supply facilities.

c. Airdrome.—Landing field with facilities for shelter, supply, and repair of aircraft.

d. Alternate airdrome.—Airfield available for use of air force units, in addition to one to which they are assigned.

e. Approach zone.—Cleared area, which allows friendly aircraft to see the field at a distance and come in at a low glide.

f. Apron.—Surfaced or paved area used for parking, servicing, and maintenance of aircraft.

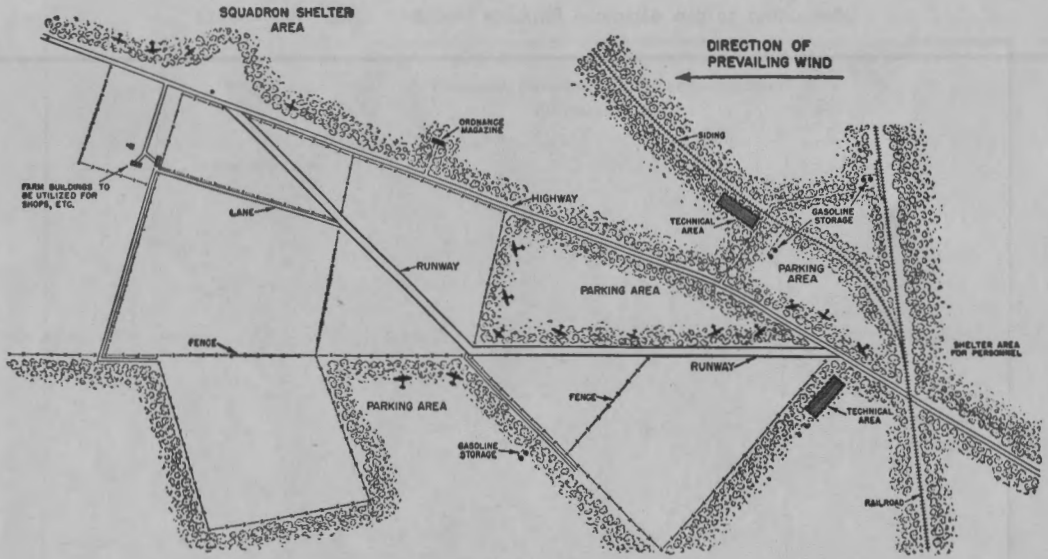


FIGURE 128.—Field airdrome. Note how runways and taxiways are laid out to fit existing road pattern, which makes it much easier to camouflage. Airplanes are widely dispersed and concealed in edge of bordering woods. One runway is always laid out in the general direction of the prevailing wind.

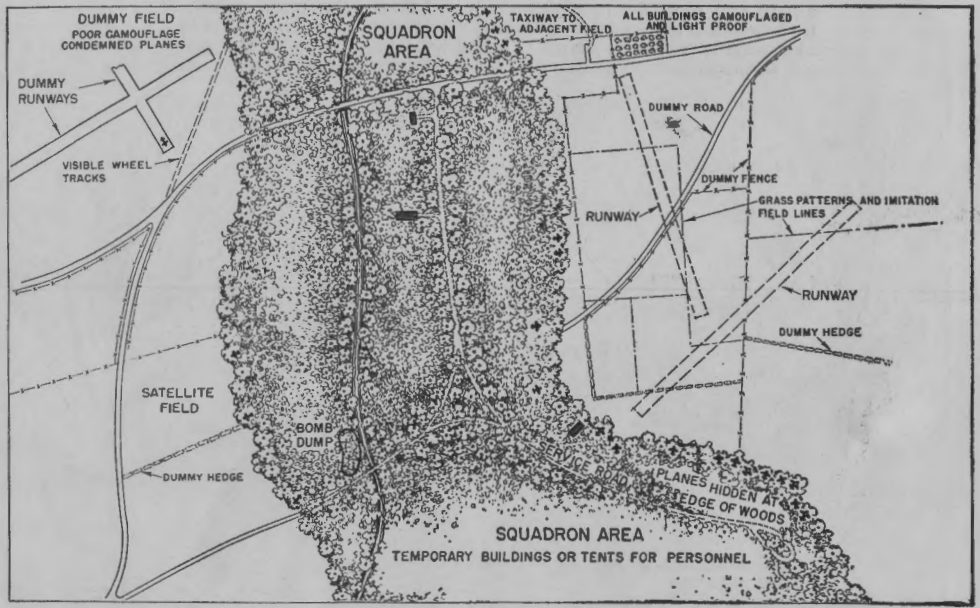


FIGURE 129.—Field airdrome showing extensive use of camouflage.

g. Dispersal parking area.—Area in vicinity of airdrome, used for dispersed (widely separated) parking of aircraft.

h. Dispersed airdrome.—Airdrome in which runways, technical facilities, and housing are spread out to aid concealment and lessen damage in event of a bomb hit.

i. Field airdrome.—Airfield built for wartime use only. It is built so as to satisfy minimum military requirements.

j. Hard standing.—Surfaced or paved area used for parking of an individual airplane.

k. Landing strip.—Prepared strip of land used for landing and taking-off of aircraft. It may or may not have a runway.

l. Runway.—Paved or surfaced strip located in the center of a landing strip. (See figs. 130 and 131.)

m. Shoulder.—Graded area adjacent and parallel to runway.

n. Staging field.—Intermediate landing and take-off area with a minimum of servicing, supply, and shelter, for temporary occupancy of military aircraft during movement from one airdrome to another.

o. Taxiway.—Surfaced or paved way primarily intended for circulation of aircraft on and near an airfield.

■ 80. THE AIRFIELD.—The building of a military airfield is an involved and complicated construction operation. In many respects it is like building a superhighway to support very heavy wheel loads. But there are certain differences from road-building which are extremely important, and with which the aviation engineer must be fully acquainted in order to accomplish his job.

a. Construction.—An airfield must be able to take, for the most part, a heavier load than a road. Where an average heavy load for a road is a 10-ton truck, a runway may have to support an 80-ton bomber. It is clear, therefore, that airfields must be built on firm, well-drained ground, with a strong base. Figure 133 illustrates how the load of a plane is distributed through the layers making up an airfield runway.

b. Surfacing.—The surface of a runway must be smooth and even, free from pebbles or loose material that may be blown into the air and damage propellers and other

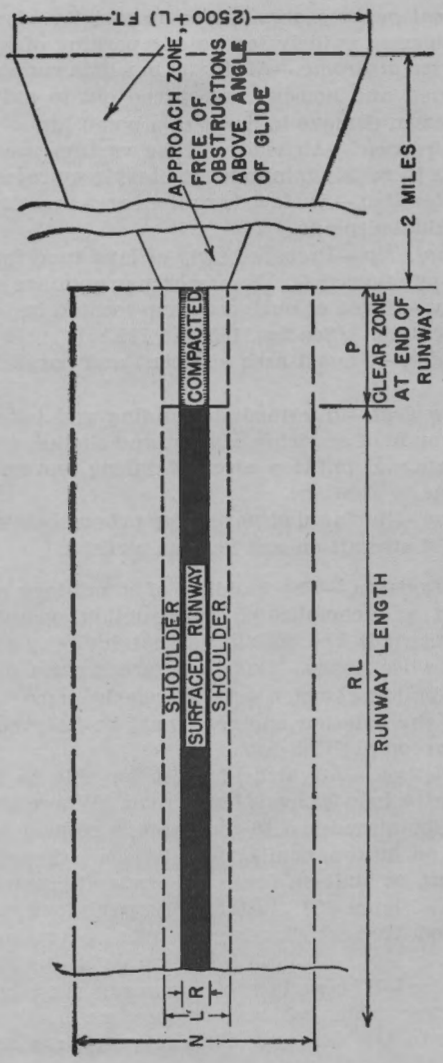
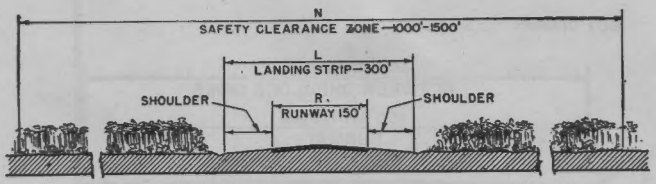


FIGURE 130.—Diagram of typical runway area.



NOTES:
(1) SHOULDERS — CLEARED, GRADED, AND DRAINED. NO OBSTRUCTION OF ANY KIND PERMITTED. AREA COMPACTED AND SEEDED OR OTHERWISE SURFACE TREATED FOR STABILITY, SURFACE DRAINAGE, AND CONCEALMENT.

(2) SAFETY CLEARANCE ZONE — EARTHWORK AND CLEARING AS SPECIFICALLY REQUIRED BY AIRDROME COMMANDER. NEW BUILDINGS OR OBSTRUCTIONS NOT PERMITTED.

FIGURE 131.—Cross section of typical runway area.

parts of a plane. Since a plane lands at very high speeds, compared with vehicles, small rocks and other obstructions that would be unimportant in a road should not be allowed to remain on the runway.

c. Length of runway.—The faster and heavier a plane, the longer the runway must be. Therefore landing fields for bombers, fighters, and light aircraft are of different lengths.

d. Camouflage.—If we can reach enemy installations from our fields, they can likewise reach our fields. It is important that our fields be hard to find, and, if found, hard to see. Therefore an airfield is laid out to take advantage of natural concealment, and every attempt is made to camouflage both the airfields and the individual planes. (See figs. 134 and 135.) This is an important function of the Corps of Engineers.

e. Figures 128 and 129 illustrate a typical airfield and how ground features are used to help conceal it.

■ 81. STEEL RUNWAYS.—Since construction of airfields requires a great deal of time and labor, the Army has looked for ways of constructing a field quickly. For this purpose we have developed prefabricated steel landing mats of various kinds, which can be laid down quickly with a minimum of tools and equipment. It is important that every engineer

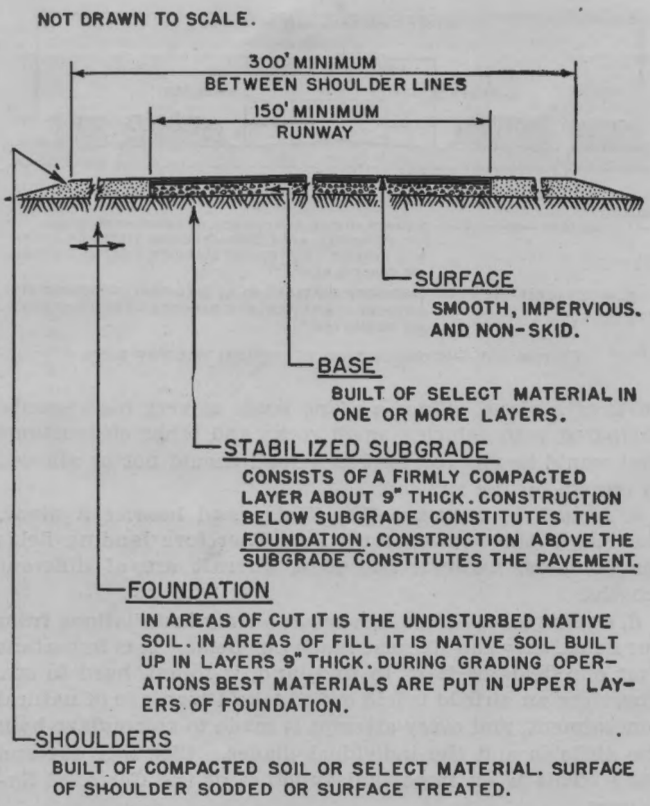

NOT DRAWN TO SCALE.
300' MINIMUM
BETWEEN SHOULDER LINES
150' MINIMUM
RUNWAY
SURFACE
SMOOTH, IMPERVIOUS, AND NON-SKID.
BASE
BUILT OF SELECT MATERIAL IN ONE OR MORE LAYERS.
STABILIZED SUBGRADE
CONSISTS OF A FIRMLY COMPACTED LAYER ABOUT 9" THICK. CONSTRUCTION BELOW SUBGRADE CONSTITUTES THE FOUNDATION. CONSTRUCTION ABOVE THE SUBGRADE CONSTITUTES THE PAVEMENT.
FOUNDATION
IN AREAS OF CUT IT IS THE UNDISTURBED NATIVE SOIL. IN AREAS OF FILL IT IS NATIVE SOIL BUILT UP IN LAYERS 9" THICK. DURING GRADING OPERATIONS BEST MATERIALS ARE PUT IN UPPER LAYERS OF FOUNDATION.
SHOULDERS
BUILT OF COMPACTED SOIL OR SELECT MATERIAL. SURFACE OF SHOULDER SODDED OR SURFACE TREATED.

FIGURE 132.—Runway pavement nomenclature.

know the essentials of laying down these steel runways. Figures 136 to 142, inclusive, show this kind of runway and the means of making connections among the various parts. These runways are simple to put together, but it is up to you to know how to handle the various parts for rapid construction.

■ 82. THE AIRFIELD AND THE ENGINEER.—*a. Maintenance.*— Building the airfield is a big job, but the engineers' job does

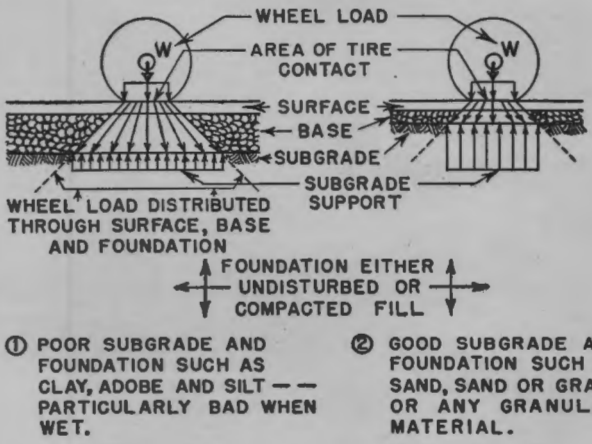

WHEEL LOAD
W
AREA OF TIRE CONTACT
W
SURFACE
BASE
SUBGRADE
SUBGRADE SUPPORT
WHEEL LOAD DISTRIBUTED THROUGH SURFACE, BASE AND FOUNDATION
FOUNDATION EITHER UNDISTURBED OR COMPACTED FILL
① POOR SUBGRADE AND FOUNDATION SUCH AS CLAY, ADOBE AND SILT — — PARTICULARLY BAD WHEN WET.
② GOOD SUBGRADE AND FOUNDATION SUCH AS SAND, SAND OR GRAVEL, OR ANY GRANULAR MATERIAL.

FIGURE 133.—Wheel-load distribution on runway.

FIGURE 134.—Airplane concealed with artificial materials—garnished half-top net, artificial trees in foreground.

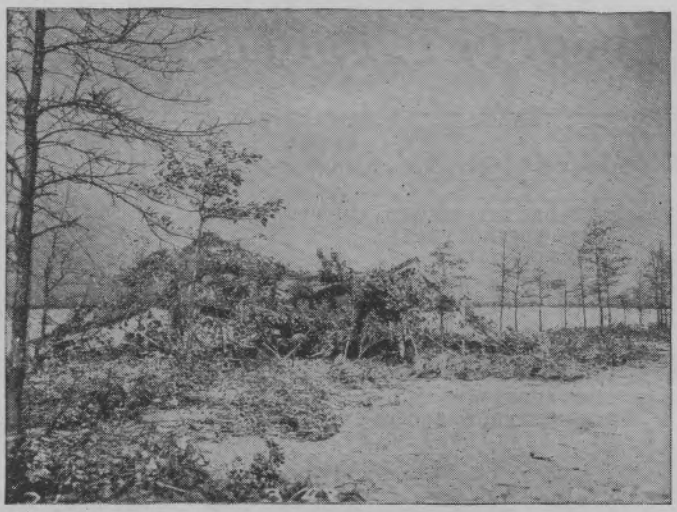


FIGURE 135.—Airplane concealed with aid of natural materials—net garnished with local foliage.

not end there. It is just as important to keep that field in a condition to be used at all times. Since the field comes under fire of various sorts, engineers must be alert and ready to fill bomb craters and to clean debris, shell fragments, and other foreign material from the runway surface. The maintenance of camouflage practice and discipline is also the engineers' job.

b. Equipment.—Aviation engineers are given much heavy machinery—bulldozers, power shovels, road graders, tractors, trucks. This material must be kept in the best of condition. These powerful machines are the engineer's tools; without them he cannot do his job. To fill a crater made by a 300-pound bomb means that 90 tons of material must be moved. With his heavy equipment, the aviation engineer can do the job in a short time; without his equipment, the job will be done too late to help the air force, too late to keep the field serviceable, too late to allow our mission to be successful. *Your equipment must be ready.*

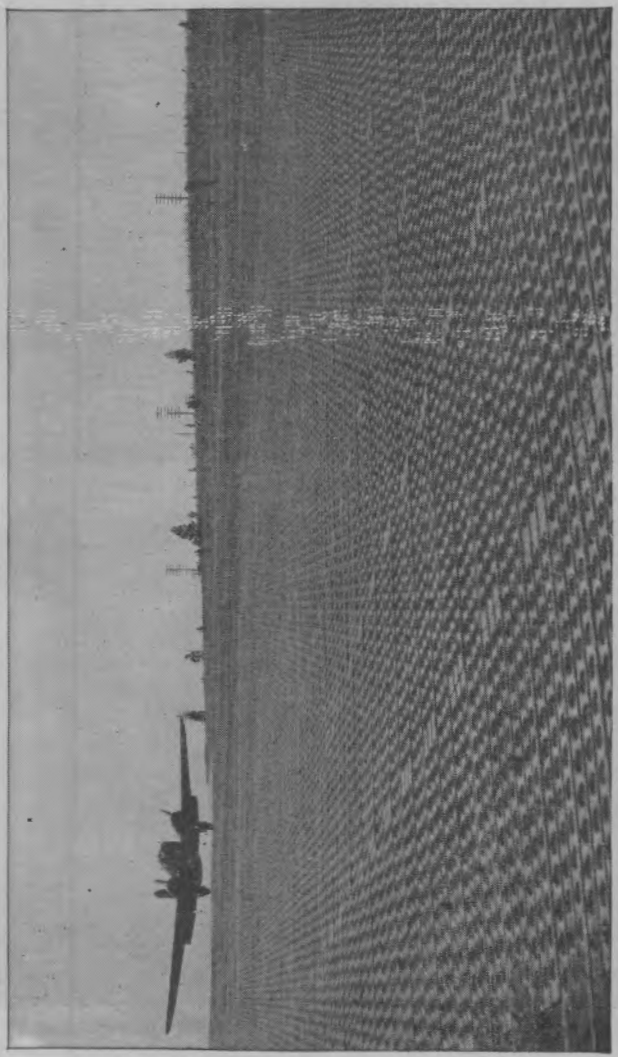


FIGURE 136.—Medium bomber landing on steel plank runway.

FIGURE 137.—Laying pierced plank steel runway.

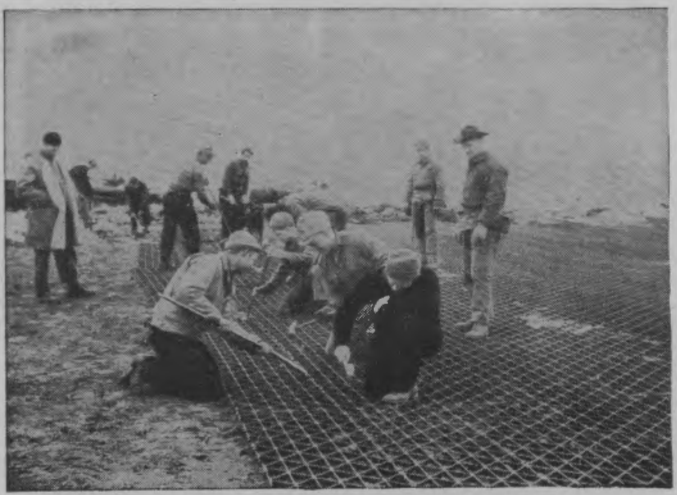


FIGURE 138.—Laying Irving grid steel runway.

FIGURE 139.—Laying bar-and-rod type steel runway.

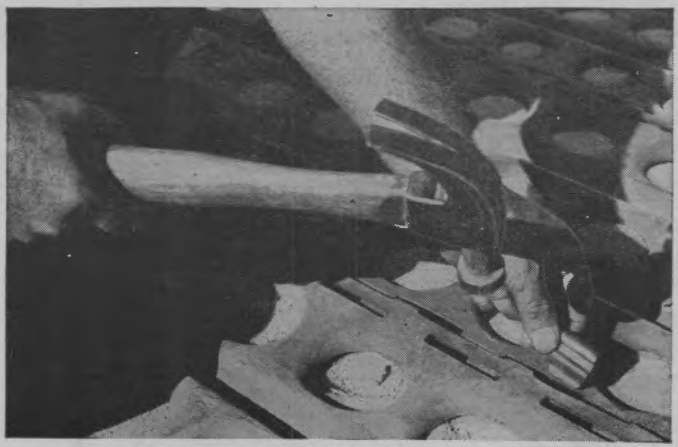


FIGURE 140.—Method of clipping pierced plank.

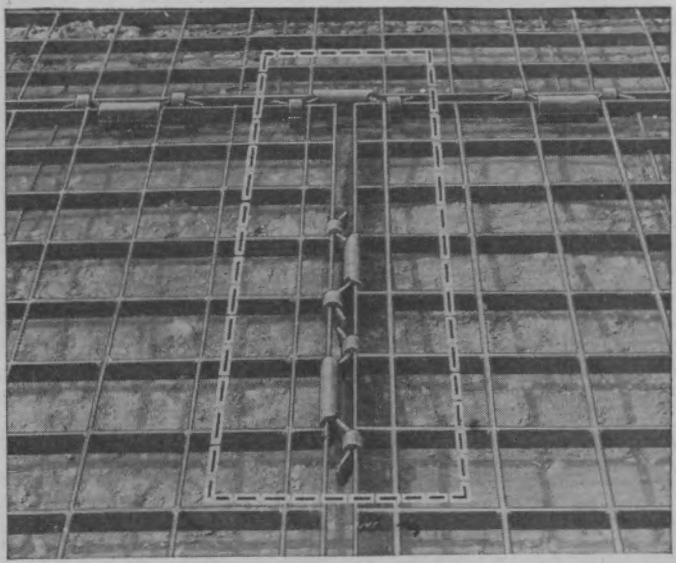


FIGURE 141.—Method of fastening bar-and-rod steel plank. (Similar connection used with Irving grid.)

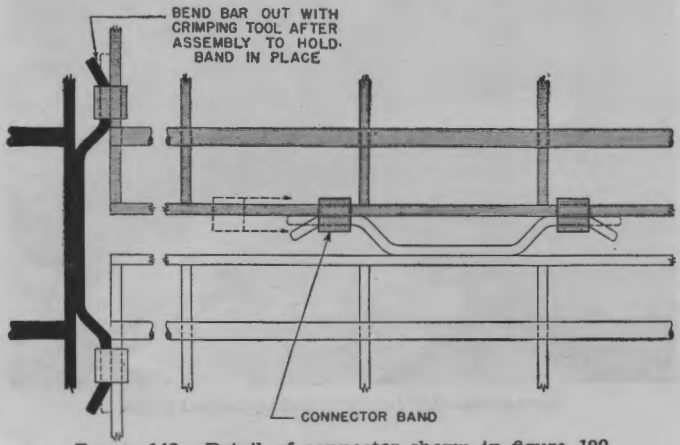


FIGURE 142.—Detail of connector shown in figure 139.

FIGURE 143.—Clearing and grading runway using bulldozers, typical pieces of heavy aviation engineer equipment.

■ 83. KEEP 'EM FLYING.—Like other Army engineers, the aviation engineer must do his utmost to prevent anything from hindering the forward and continued movement of our forces. Sure, it's a tough job, but engineers are tough soldiers. The construction and maintenance of an airfield is one of the stiffer challenges thrown to the engineer. We are meeting it successfully. Whether we continue to win the "battle of the airfields" depends upon how well you learn your job and upon the courage with which you carry it out. Keep 'em flying!

CHAPTER 12

ENGINEER RECONNAISSANCE

■ 84. GENERAL.—Reconnaissance means the obtaining of information by going out and getting it. Engineers need a great deal of special kind of information to carry out their jobs. As an engineer soldier you may frequently accompany a reconnaissance party; you must know what you are looking for. A good engineer reconnaissance man has two essential qualities:

a. He must be continually alert.

b. He must be able to determine the importance to an engineer of everything he sees.

■ 85. WHAT TO LOOK FOR.—You should, at all times, be alert to engineer needs for information. Some of the things which engineers are interested in are—

a. Engineer materials.—(1) Lumber piles.

(2) Quarries and gravel pits.

(3) Standing timber.

(4) Civilian building materials, machines, and tools.

(5) Standing buildings which may be repaired, or whose lumber may be used for other purposes.

(6) Road-building materials.

b. Roads.—(1) Condition.

(2) Type (earth, hard-surface, etc.)

c. Bridges.—(1) Condition.

(2) Length.

(3) Type.

(4) Number and size of stringers.

d. Obstacles.—(1) Type.

(2) Extent.

e. Streams.—(1) Width.

(2) Depth.

(3) Current.

(4) Banks.

(5) Approaches.
(6) Dams.
f. Utilities.—(1) Power and communication lines.
(2) Water supply facilities.

■ 86. WHAT TO DO ABOUT IT.—*a.* The things you see are useful only if the information can be used, *in time,* by your commander. Once information is secured by a reconnaissance scout, *the first thing to do is to get it to the commander in time to be of use.* A little information in the hands of the commander is better than a lot of information in the hands of a scout who arrives too late.

b. Your information should be in writing and arranged in an orderly manner. Your notes should include as many of the essentials as you have time to find out. When you come back you should be able to point out on a map the location of everything you saw.

CHAPTER 13

THE ENGINEER AND HIS TRUCK

■ 87. ENGINEERS RIDE.—Since engineers pave the way for an army's advance, they must be able to keep up with, and even precede, the fastest-moving elements of the army. Whenever possible, engineers ride in motor vehicles, carrying their tools and equipment with them; however, they must be able to go long distances on foot when necessary, and work and fight afterward.

■ 88. YOUR RESPONSIBILITY TO YOUR VEHICLE.—Means of transportation is as important to an engineer soldier as a rifle is to an infantryman. The engineer works with tools and gets to the scene of trouble quickly; his truck contains his tools, collects his materials, and gets him to the job; in fact, his job is built around his equipment. Therefore, one of your most important duties is to keep your vehicle in perfect condition. You are a useless engineer if you can't get to the scene of action in time; you are a useless engineer if you can't bring your tools with you.

■ 89. CARE OF VEHICLES.—The good condition of your truck depends on proper driving, proper lubrication, proper and prompt maintenance. All three are important; all three demand your utmost attention. Treat your vehicle like a strong but temperamental horse.

a. Give it its due share of attention.

b. Don't fail to give it the right amount of water and oil at the right time.

c. Keep it clean.

d. Inspect it carefully and frequently and tighten all loose parts.

e. Attend *at once* to anything that needs to be repaired or replaced.

f. Think of and attend to the needs of your vehicle before you think of your own needs.

g. Learn all you can about good driving. Every engineer soldier who drives or maintains a vehicle should read FM 25–10, in order to be a better driver, a better engineer, a better soldier.

CHAPTER 14

COMBAT WEAPONS

■ 90. FIGHTING ENGINEERS.—The big job of engineers is construction and demolition in order to assist our movement and hinder that of the enemy. That job doesn't leave much spare time for fighting. However, the engineer is a scrapper and is given combat weapons with which to protect himself at work and so that he can reinforce the infantry when necessary.

■ 91. COMBAT WEAPONS.—The principal weapons of the combat engineer and their characteristics are as follows:

a. Hand grenades.—(1) *Offensive grenades.*—Depend upon blast effect only. No fragmentation. Effective bursting radius—5 yards. Should be used when thrower lacks cover to protect himself from flying fragments. Can be used for light demolitions and as priming charge for heavier demolitions.

(2) *Defensive grenades.*—Fragmentation type. Bursting radius—30 yards. Can cause casualties up to 200 yards. Should be thrown from covered positions, or into fox holes, trenches, or other enclosures, to prevent injuries to thrower. An excellent weapon against crew-served weapons in emplacements.

(3) *Smoke grenades, WP or HC.*—Used to conceal your own activities, or to blind the enemy and hamper his fire and movement. HC has a slight irritant effect. WP can cause severe burns.

(4) *Frangible grenades.*—For antitank incendiary use. Consists of a glass bottle filled with gasoline, or other inflammable material with an igniter, which causes it to burst into flame when broken. Effective when thrown into open tank hatches or air intake ports.

(5) *Thermite grenades.*—For destruction of material. Emits white-hot molten metal that burns through light

metal. Useful in igniting gasoline or oil in drums or other inflammable materials in metal containers.

b. Antitank rifle grenade discharger.—A short-range antitank rifle grenade, projected from a discharger fitted on a caliber .30 rifle. Maximum range against tanks is 75 yards. Penetrates any known light or medium tank. Penetration not influenced by range.

c. Antitank rocket discharger ("bazooka").—An armor-piercing weapon that breaches armor of any known light or medium tank. Much more powerful than antitank rifle grenade. Maximum effective range under favorable conditions is 300 yards, beyond which it is comparatively inaccurate. Penetration not affected by range. Primarily an antitank weapon, though it may be used effectively against crew-served weapons and point targets other than tanks.

d. Bayonet.—For shock action. All crack troops are good bayonet fighters.

e. Pistol, caliber .45.—A self-loading weapon carried by senior officers for close protection.

f. Submachine gun, caliber .45.—A short-range automatic weapon, excellent for close combat in an emergency situation.

g. Carbine, caliber .30.—A self-loading weapon, very effective up to 300 yards. An excellent medium-range rifle, very light and handy. Issued to company officers, key noncommissioned officers, officers, and messengers in combat battalions; is basic arm for rear area.

h. Rifle, caliber .30, M1.—A self-loading weapon, very effective up to 600 yards. The fundamental engineer combat weapon and the best of its type.

i. Machine gun, caliber. .30, heavy.—A water-cooled automatic weapon, capable of a high rate of sustained fire. Used to provide base of fire in attack. Lays down final protective lines and covers sectors of fire in organized defenses. Excellent for covering mine fields and obstacles to prevent their removal. Covers approaches to bivouacs and working parties.

j. Machine gun, caliber .30, light.—Automatic air-cooled weapon, with a comparatively low rate of sustained fire.

k. Machine gun, caliber .50.—When suitably mounted, an effective anti-aircraft weapon, especially when rounds in belt contain mixture of tracer, armor-piercing, and incendiary

bullets. Also excellent for knocking out trucks and lightly armored vehicles.

■ 92. GENERAL.—The following fundamentals should be remembered by every soldier—

a. Know your weapons and be able to hit with them.

b. Always take your weapons to work and keep them ready for use. Every job must have local security.

c. Shoot only when you have something to shoot at and are reasonably sure of hitting your target. It is a recruit trick to disclose a maneuver or position by firing too soon. This probably is the worst individual mistake in combat.

APPENDIX I

ENGINEER ORGANIZATIONS AND ENGINEER SPECIALISTS

■ 1. ENGINEER ORGANIZATIONS.—The Corps of Engineers does many different kinds of work. Much of this work is of a special technical nature. It is so technical, in fact, that whole engineer units—companies, battalions, regiments—are designed to do only one particular kind of job. Following is a list of some of the types of engineer units and what they do.

a. Engineer general service combat units.—The basic engineer units are combat troops of various kinds, and can be used for any type of engineer work. These include—

(1) *Airborne battalion.*—Combat engineers for airborne division.

(2) *Armored battalion*—Combat engineers for the armored force.

(3) *Combat battalion.*—Combat engineers for infantry division.

(4) *Mountain battalion*—Combat engineers for mountain division.

b. Engineer special units.—(1) *Aviation regiment.*—Does work similar to the aviation battalion, but operates where a large volume of work is concentrated in a small area.

(2) *Aviation battalion.*—Builds, defends, and maintains airfields; uses much heavy equipment.

(3) *Airborne aviation battalion.*—Makes hasty repairs to captured airdromes for early use by our air forces.

(4) *Air force headquarters company*—Performs necessary drafting, designing, surveying, planning, reproduction, and camouflage work for the air force engineer.

(5) *Camouflage company, camouflage battalion.*—Supply camouflage materials; supervise and inspect camouflage installations.

(6) *Depot company.*—Operates engineer supply depots for field units.

(7) *Dump truck company.*—Operates and maintains a fleet of dump trucks for use in engineer work.

(8) *Equipment company.*—Furnishes operators and heavy engineer equipment.

(9) *Forestry company.*—Operates sawmills and supplies lumber to engineer units.

(10) *General service regiment.*—Highly skilled carpenters, operators, and builders; uses much heavy equipment.

(11) *Heavy shop company.*—Does heavy repair work for heavy engineer equipment.

(12) *Light equipment company.*—Furnishes light mobile construction equipment for combat battalion.

(13) *Maintenance company.*—Does third echelon maintenance on all kinds of engineer equipment, but not on vehicles which are for ordnance use.

(14) *Ponton company, ponton battalion.*—Maintain, transport, and build floating bridges.

(15) *Separate battalion.*—Large labor unit; builds roads, buildings, airfields, etc.

(16) *Topographic companies, topographic battalions.*—Make and reproduce maps of all kinds for field forces.

(17) *Treadway bridge company.*—Maintains, transports, and builds the steel treadway bridge of the armored force.

(18) *Water supply company.*—Uses mobile purification units and tank trucks to purify and supply drinking water.

■ 2. ENGINEER SPECIALISTS.—Experience and skill gained in many civilian occupations are especially needed in engineer units. In every engineer unit there are numerous specialists who receive high ratings. Qualifications for occupational specialists are prescribed in AR 615–26. The number in parentheses is an important part of each specialist designation. Some of the many specialist designations most needed in general engineer units are listed below, together with similar civilian occupations from which such specialists are usually secured.

Military specialists	*Civilian occupations*
Blacksmith (024)_____	Machine-shop blacksmith, blacksmith, forge shopman, or general blacksmith.

Military specialists	*Civilian occupations*
Bridge carpenter (053).	Mine carpenter, railway carpenter, mine timberman, general construction carpenter.
General carpenter (050)	House carpenter, mill carpenter, carpenter's helper.
Chauffeur (245)	Chauffeur automobile driver, road tester, automobile mechanic.
Demolition man (027)	Explosive man, quarry foreman, mine boss.
Draftsman, general (070).	Detailer and tracer, draftsman.
Electrician, general (078).	Wireman, light wireman, electrician.
Jackhammerman (190).	Pneumatic tool operator, riveter, boilermaker.
Mechanic, general (121).	Skilled helper, handy man (must be able to work from simple drawings or sketches).
Operator, air-compressor (699).	Air-compressor operator, automobile mechanic, tractor driver.
Painter, general (144)	Fresco painter, large sign painter, house painter.
Pipe fitter (162)	Steam fitter, plumber.
Rigger, general (189)	Machine erector, structural steel erector, bridge erector.
Road roller operator (244).	Same as tractor driver.
Sheet metal worker (201).	Tinsmith, plate worker.
Storekeeper (186)	Receiving and shipping clerk, shipping clerk, warehouse clerk.
Tractor driver (244)	Portable gasoline engineerman, tractor field expert, tractor demonstrator, truck driver.
Welder (256)	Welder, subdivisions; blacksmith, general.
Winch operator (063)	Hoister engineerman, stationary engineerman.

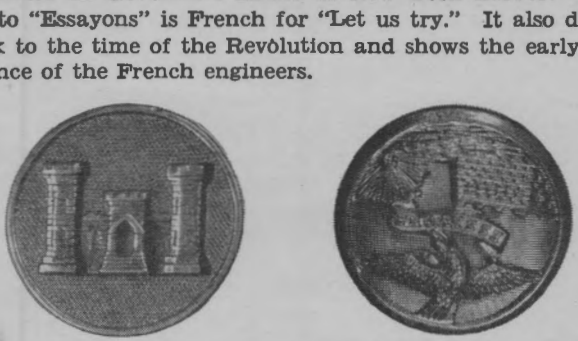
APPENDIX II

ENGINEER INSIGNIA

The turreted castle (fig. 144) is the distinctive insignia of the Corps of Engineers. It was first used during the Revolutionary War and has been used in various forms since that time. Introduced by French officers, who were part of our first Corps of Engineers, it apparently was modeled after one of the gates of the city of Verdun, France. It differs from engineer insignia now in use by any foreign army. The turreted castle serves as a reminder of fortification work which has been an important task of military engineers from ancient times up to the present.

Engineer colors are scarlet and white. The chief color, scarlet (used by both artillery and engineers), is more prominently displayed. White is used as a piping (edging) or for similar purposes, as on the engineer hat cord and guidon.

The officers of the Corps of Engineers do not wear the button with the coat of arms of the United States which is worn by all other officers. They have a different button bearing a fortification (fig. 144) modeled after an early structure on Governor's Island in New York harbor. The motto "Essayons" is French for "Let us try." It also dates back to the time of the Revolution and shows the early influence of the French engineers.



① Enlisted man's collar ornament. ② Officer's coat button.
FIGURE 144.—Engineer insignia.

The colors (flags) of engineer organizations consist of two silk flags with fringes; one is the flag of the United States and the other that of the engineer organization. The latter is scarlet embroidered with a coat of arms similar to that of the United States, except that the shield and crest of the organization are substituted for those of the United States seal. Streamers with the same distinctive colors of corresponding service ribbons, attached to the head of the staff of the engineer organization color, show battle honors (military campaigns) in which the unit has taken part. Many organizations have a coat of arms symbolizing the history of the organization which, in some cases, dates back to the Mexican and Civil Wars.

APPENDIX III

PROFICIENCY TESTS FOR ENGINEER SOLDIERS

In this mechanized war we are fighting, you have an increasingly important role. You are trained to fight; but more important, you are trained as a technical specialist to do all types of engineering work required to aid the advance of our troops and to stop the advance of the enemy. Theoretically, each engineer unit is a team of specialists trained to do a certain task. Actually, the uncertainties of war require every engineer soldier to know the fundamentals of every branch of military engineering. For example, you must know how to place a demolition charge that will be sure to go off when you fire it. One or two of you may be detailed to demolish an important structure. *You must not fail.* In fast-moving war, you may find yourself manning a 37-mm antitank gun or a caliber .50 machine gun when you are not a regular member of the crew. You must be proficient in all measures of individual protection and security. You must know your *engineering* and your *combat principles.*

The proficiency tests that follow give you a chance to check up on what you have been taught, to review the things you must know, and to record your progress toward the standard set for you.

Carry this book with you during duty hours. As soon as you feel qualified to answer the questions or perform the tasks of a test, see your nearest company officer. He will conduct a test as soon as practicable. If you pass, he will initial the question or demonstration and record his name. The development of your abilities as an engineer soldier has an important bearing on your progress in the Army.

CHECK LIST NO. 1—*General*

1. What is the name and rank of your battalion commander?

2. What is the name and rank of your company commander?

3. What is the name and rank of your platoon commander?

4. What are the names and ranks of the other company commanders in the battalion?

5. What clothing and equipment do you carry in your combat pack, roll, barracks bag?

6. Are the data on your identification tags correct? Why are the tags tied as they are?

7. What information will you give the enemy, if captured?

8. Using your mess gear, demonstrate how to prepare coffee, cocoa, stew, boiled potatoes, fried eggs, and bacon?

9. Under what circumstances do you lay aside your rifle when working?

10. *a.* How would you draw your pay if you were separated from your unit?

b. What entries must be made in your Soldier's Pay Card (W. D., A. G. O. Form 28, p. 2), before you can do so?

CHECK LIST NO. 2—*Unit organization and equipment*

1. What bridge equipment does a combat battalion carry in the field?

2. How many reconnaissance boats are there in a combat company?

3. *a.* What pneumatic tools are there with the compressor truck?

b. How many of these tools may be used at the same time?

c. How and for what purpose are they used?

4. Name tools carried in your squad pioneer, carpenter, and demolition chests.

5. What quantities of the following expendables are ordinarily carried with the squad sets: explosives, fuze, caps, rope, wire, sandbags?

6. Demonstrate how to place tools in proper places in squad boxes.

7. What transportation is assigned to your unit?

8. What is the strength of your company?

9. What is the strength of your battalion?

CHECK LIST NO. 3—*Bridges, fixed and floating*

1. Define following terms applied to bridges:

Abutment	Suspension
Approach	Floor beams
Truss	I-beams
Girder	Reinforcing
Pier	

2. Identify following parts of ponton, assault, and reconnaissance boats:

Valve	Capstan
Balk fastener	Bow
Paddle	Cleat
Oar	Bulkhead
Gunwale	Stern

3. Know how to carry, launch, and paddle an assault boat silently. Know how infantry are loaded.

4. Know how to carry, launch, and paddle a reconnaissance boat.

5. Know how to carry, launch, and row a ponton boat.

6. Know how to repair a rubber boat.

7. Know how to carry balk and chess.

8. Know parts of abutment of any bridge and their relation to each other.

9. Identify the following parts of the standard timber and trestle bridge:

Cap	Treads
Sill	Bracing
Post	Span
Bent	Abutment sill
Stringer	End dam
Curb	Approach
Footing	Roadway
Floor	

10. Know how to strengthen an existing bridge.

11. Identify the following parts of floating bridges:

Balk	Trestle
Chess	Raft
Siderail	Abutment sill
Siderail clamp	Ponton

Holdfast
Hinge span
Bay
Pneumatic float

12. Know what working parties are required for construction of a footbridge and duties of each.

13. Know what maintenance is required on a ponton bridge.

14. Know the regulations for traffic using a ponton bridge.

15. Know how to construct a float using rifles and shelter halves.

16. Know how to construct a raft using 55-gallon gasoline drums, 3-inch planks, and ¾-inch rope.

CHECK LIST NO. 4—*Camouflage*

1. Know the purpose of camouflage.

2. Know types of observation against which camouflage is required.

3. Know how and with what to camouflage the following:

a. Yourself.
b. Your foxhole.
c. Your tent.
d. Your truck.
e. Your machine-gun position.

4. Know how to garnish a camouflage net with natural or artificial materials.

5. Know five precautions to take to preserve camouflage discipline in a bivouac area.

6. Know how to use shadows to hide a truck in the morning; in the afternoon.

7. Know how to break up shadows cast by military installations and equipment.

8. Know what camouflage measures should be taken on a march; at a halt.

9. Know how to use natural materials in locating your shelter tent.

10. Know why new tracks must not be formed around a military installation.

CHECK LIST NO. 5.—*Demolitions*

1. Know safety rules for using gunpowder, dynamite, nitrostarch, TNT, primacord, caps.

2. Know precautions to be taken before and during firing of a charge.

3. Know precautions to be taken in event of a misfire.
4. Know how to prepare and light safety fuze, using safety match; fuze lighter.
5. How long does it take to burn 1 foot of safety fuze? 6 feet? Test.
6. Know how to prepare a cap and safety fuze for firing.
7. Know difference between time fuze and primacord.
8. Know how to prepare primacord for detonation.
9. Know how to join two pieces of primacord; demonstrate.
10. Know how to make a primer using nonelectric cap and fuze; electric cap; detonating cord.
11. Know how to make a series connection of electrical caps.
12. Know how to prepare a wire splice correctly.
13. Know how to test a circuit by use of the galvonometer.
14. Know cap capacity of the exploders.
15. Know how to fix a demolition charge to—
    a. A rail.
    b. A post or tree (internal or external).
    c. A girder.
    d. A concrete beam.
    e. An I-beam.
16. Know effect and value of tamping and how to obtain it.
17. Know proper method of placing and firing underwater charges.
18. Know how to handle standard firing devices.
19. Know how to lay and arm an antitank mine.
20. Know three methods of removing an activated enemy antitank mine.

CHECK LIST NO. 6.—*Engineer reconnaissance*

1. Estimate height of building or tree (within 15 percent error).
2. Measure height of building or tree (within 10 percent error) by comparing shadow cast by object with length of your own shadow.
3. Measure gradient of a road with a clinometer.
4. On a map point out places to look for—
    Sand
    Gravel
    Timber
    Quarry
    Water

5. Know what reconnaissance information is needed about—

Roads
Bridges
Obstacles and mine fields
Stream crossings
Water supply
Power and communication lines.

6. Know what reconnaissance information to send, to whom, when to send it, and where it should be sent.

CHECK LIST NO. 7.—*Field fortifications and obstacles*

1. What is the minimum clearance required in a one-man standing type of fox hole for protection against tanks passing directly over the fox hole?
2. What are the approximate dimensions of a—
   One-man fox hole (standing)
   Two-man fox hole (standing)
3. Know how to distribute spoil when digging trenches and fortifications.
4. What thickness of loose earth is proof against small-arms fire?
5. Know how to build a wall revetment.
6. Know how a double-apron fence is constructed.
7. Know the fastenings for barbed wire on screw pickets.
8. Know how to cut a path through wire fence with wire cutters.
9. Know how to prepare and place a bangalore torpedo for cutting path through wire fence.
10. Know how to build at least two kinds of log tank obstacles.
11. Know the minimum dimensions of antitank ditches required to stop tanks.
12. Know what type locations are suitable for road blocks.
13. Know how to make a hasty emplacement for heavy machine gun, caliber .30.
14. Know how and why obstacles are *covered* by fire. Know how and why they are *protected* by fire.
15. Know how to install obstacles against airplanes attempting to land.

CHECK LIST NO. 8.—*First aid—military sanitation—sex hygiene*

1. Know what first-aid equipment is in your first-aid packet.
2. Demonstrate first aid you would give in case of—
   a. Drowning.
   b. Bad knife wound in arm; in neck.
   c. Broken leg.
   d. Shock.
3. Know best method of preventing venereal disease.
4. Know what to do in case you contract venereal disease.
5. Know how to take care of your feet on long marches.
6. Know how to prevent spreading your "cold."
7. Know how to chlorinate a canteen cup of water.
8. Know another method of purifying a canteen cup of water in the field.
9. What is water discipline on the march?

CHECK LIST NO. 9.—*Gas defense*

1. What is the gas alarm?
2. Know how to put on, adjust, test, and remove a gas mask properly.
3. Know the field identification of the following military gases by smell:

Mustard	Chlorpicrin
Lewisite	Tear gas
Chlorine	Adamsite
Phosgene	

4. Which gases are vesicants? which are lung irritants? which make you cry?
5. What do you do when you hear the gas alarm?
6. What is the last thing you do before taking off your gas mask?
7. What first-aid measures will you take for a casualty by a vesicant gas? By a lung irritant gas?
8. Know how to decontaminate—
   A rifle.
   Personal equipment and clothing.
   A bridge to be prepared for demolition.

9. Know what action should be taken if a gassed area is found.
10. Know for what purpose protective clothing is used.

CHECK LIST NO. 10.—*Knots, lashings, and rigging*

1. Know how to coil and uncoil rope.
2. Know how to tie the following knots and their uses:

Bowline	Fisherman's bend (anchor knot)
Bowline on a bight	Round turn and two half hitches
Square knot	Timber hitch
Sheep shank	Mooring hitch
Single sheet bend	
Clove hitch	

3. Know how to whip the end of a rope; mouse a hook.
4. Know how to make a square lashing.
5. Know how to make a short splice; a long splice; an eye splice.
6. Name parts of a set of double blocks; know how to reeve them.
7. Know how to make lashings for gin pole, shears, and tripod.
8. Know where to fix guys to shears and gin pole.
9. Know mechanical advantage of various types of tackle.
10. Know precautions to prevent damage to steel cable.
11. What is the strength of ½-inch rope? ¾-inch rope? 1-inch rope?
12. What is the strength of ½-inch steel cable? ¾-inch cable? 1-inch cable.
13. Know how to make a 3–2–1 picket holdfast.
14. Know capabilities and characteristics of chain; chain hoist; chain ratchet hoist.

CHECK LIST NO. 11—*Map reading*

1. Know how to determine grid coordinates of a point indicated on a map.
2. Know how to orient a map with and without a compass.
3. Given two points on a map, know how to scale shortest road distance between them, in miles.

4. Given two points on a contour map, know how to determine their relative heights.

5. Be able to identify on a contour map—

Hill	Saddle
Steep slope	Cut
Streams	Fill
Ridge lines	Marsh

6. Be able to identify on a map—

Railroad line	Bridges
Highway	Church
Trail	School
Crossroad	Fence
Road junction	Telegraph lines
Woods	Buildings

7. Be able to identify on an aerial photograph—

Roads	Houses
Woods	Fields

8. What is the difference between magnetic, true, and grid north?

9. Be able to determine north by watch and sun; by compass; by north star and dipper.

10. Know how to determine azimuth from one point to another on map; on ground.

11. Know how to determine slope and visibility from contour map.

CHECK LIST NO. 12.—*Physical conditioning*

1. Do 28 push-ups.

2. Run 300 yards in 45 seconds.

3. Carry a man of approximately your own weight 75 yards in 20 seconds.

4. Alternately run 10 yards and crawl 10 yards to cover 70 yards in 20 seconds.

5. In full field equipment, march 4 miles in 50 minutes.

6. Run the battalion obstacle course in ——— seconds.

7. In full field equipment, run 200 yards to firing point and score at least three hits out of five rounds on a silhouette target in 1 minute at a range of 200 yards.

8. In full field equipment march 30 miles in 14 hours.

9. Demonstrate how to attack a sentry from behind and kill him silently.

10. Demonstrate how to fight with a knife.

11. Demonstrate how to disarm a man armed with a rifle, pistol, knife.

12. Demonstrate at least four paralyzing blows.

13. Jump off in deep water, straighten out, swim 50 yards. Swim 25 yards in full uniform.

CHECK LIST NO. 13.—*Roads*

1. What is the most important thing to remember in all road construction?

2. What is the width of a one-lane road? Of a two-lane road?

3. Know characteristics of a road made with:

Earth	Gravel
Wire mesh	Macadam
Sandbags	Bituminous material
Corduroy	Concrete
Plank tread	

4. Know following items of equipment and what they are used for:

Plow	Roller
Scraper	Power shovel
Angledozer	Dragline
Blade grade	Rooter
Scarifier	

5. Know the meaning of the following terms:

Clearing	Shoulder
Grubbing	Culvert
Subgrade	Riprap
Drainage	Scour
Road metal	Revetment
Aggregate	Gradient
Crown	Ditch
Headwall	

6. Know how to repair a crater in a road.

CHECK LIST NO. 14.—*Rough carpentry*

1. Know how to lay out a right angle by the 3–4–5 method.
2. Know how to square abutments with center line of a bridge.
3. Using level, square, and chalkline, know how to square a round timber; a cap.
4. Know how to plumb an upright, using a level.
5. Be able, using a carpenter's square, to mark a timber for a 45° cut.
6. Drive 10 consecutive nails without bending one.

CHECK LIST NO. 15—*Tools and their use*

1. Know correct use of pick and shovel.
2. Know proper use of a gooseneck wrecking bar.
3. Know proper use of a carpenter's adz; a hatchet.
4. Know proper handling of a chopping ax; of a hand saw; a two-man saw.
5. Know how to use a peavy correctly in handling a 12-inch log.
6. Know how to fell a tree in a given direction.
7. What is the difference between a crosscut and a rip saw?
8. Know how to sharpen an ax.
9. Know how to operate properly the gasoline-driven chain saw.
10. Know how to operate properly the following compressed air tools: timber chain saw, rock drill, auger, circular saw, air hammer.

CHECK LIST NO. 16—*Weapon training*

1. How many rounds fill the magazine of a—
   a. U. S. rifle, M1.
   b. U. S. rifle, M1903.
   c. Submachine gun, caliber .45.
   d. Carbine.
2. Know sight picture of weapon with which you are armed.
3. With rifle with which you are armed, know how to—
   a. Zero rifle.
   b. Use sights.

c. Aim.
d. Press trigger.
e. Fill clips, and load clip into magazine.
f. Load and fire piece.
g. Clean after firing.

4. Know how to load, aim, and fire following weapons:
a. Heavy machine gun, caliber .30, M1918.
b. Machine gun, caliber .50 HB.
c. Antitank rifle grenade.
d. Rocket launcher.

5. What is effective range, maximum range, and normal rate of fire of weapon with which you are armed?

6. Know how to field strip and name all parts of weapons with which you are armed.

7. How do you identify ball ammunition, blank ammunition, tracer ammunition, armor-piercing ammunition, dummy ammunition?

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